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# CONTENTS

## Articles

- DENNINGER L. L.: Utilization of silk, use of webs, and predatory behaviour of the jumping spider *Paradisiaus caryopagus* (Araneida: Salticidae) ..... 141
- FARRAR L.: Sixteen new species of *Leontes* from Asia (Coleoptera: Curculionidae: Nephelini) ..... 145
- HEMER L.: Revision of species of the genus *Mordellistena* from Central region. Part I. (Coleoptera: Mordellidae) ..... 151
- JAGGER V. & NYKA I.: Assessment of *Amblyseius turkici* (Acarina: Phytoseiidae) as a natural agent for mites on greenhouse cucumbers ..... 171
- KINOSHITA T.: Review of *Scorpanella* from Thailand with descriptions of *Trachysoma rubicundus* gen. et sp. n. and *Lychnis flava* sp. n. (Bambidae) ..... 187
- RUUSKA A., AARAS M., BIRNIE P., LEE M. & WILSON P.: Mammalian fauna of the Svirsky Nos (Karelia and Leningrad), the Bialy Lake, Russia ..... 209
- SCHMIDT J. & CHERRY P.: Ecological preferences of epigaeic spiders (Araneida) in the system of dairy biotopes ..... 227
- SHIBATA P.: New species of *Anisotoma* from China (Coleoptera: Dermaptera) ..... 233
- VIRCH J.: Mating behaviour of *Aphodius* (Chalcididae) *distans* (Coleoptera: Scarabaeidae: Aphodini) ..... 249
- ZALOTSKA A.: The structure and the development of the ductus and sacculus endolymphatici in *Affigitor melanopneustes* and *Pharyngophagus versicolor* (Regina) ..... 267
- Obituary**
- SHIBATA M.: In memoriam Professor Ota Ohta ..... 273
- Book review**
- BALAZS E.: Zoogeography of Fresh Waters. I. General Distribution and Dispersal of Freshwater Animals - by V. Kottler ..... 164

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Utilization of silk, use of webs, and predatory behaviour of the jumping spider  
*Pseudicius encarpatus* (Araneida: Salticidae)

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Web construction, nest, predatory behaviour, *Pseudicius encarpatus*, Salticidae, Araneida

**Abstract.** *Pseudicius encarpatus* builds two types of nests: the densely woven cocoon-like or tubular nests for molting, oviposition and over-wintering, and less thick woven, dome-shaped or tent-shaped resting nests. Besides of nests the females *P. encarpatus* build sparsely woven three-dimensional structure of arrays, the "mesh" which they use for prey-capture. However, both sexes of *P. encarpatus* can catch the prey as cursorial hunters, as well. Predation behaviour away from and in the web is described.

#### INTRODUCTION

The Salticids are cursorial, diurnal hunting spiders with acute vision, which they use to stalk, chase and leap on active insects. Recently, however, salticids were found which catch a prey as cursorial hunters but spin prey-catching webs as well (Jackson & Blest 1982, Jackson 1985a, 1985b, 1985c, Jackson 1986a, Jackson & Hallas 1986a, 1986b, Hallas & Jackson 1986, Jackson 1990, Jackson & Pollard 1990, Richman & Jackson 1992). All these unusual, aberrant salticids are mostly tropical and they are generally considered to be primitive (Wanless 1984, Jackson 1986a). *P. encarpatus* is not generally considered to be primitive, although it exhibits, at least in some species, some "primitive" behavioural characters (Jackson 1986b). *P. encarpatus* is the first European salticid in which the building of prey-catching webs was observed.

#### MATERIAL AND METHODS

30 adult males and 6 adult females of *Pseudicius encarpatus* (Walckenaer, 1802) were observed in the field in Velehradek (Eastern Bohemia, near Dvůr Králové n.L.) from April 29 to June 2, 1994 on trunks of very old cherry trees. The observed unequal sex ratio corresponds well with data given by Puhn & Gherasim (1984). In the studied biotope *P. encarpatus* lives sympatric with less common *Salticus rebaurens* (C. L. Koch, 1837) and *Stiphodon pubescens* (Fabricius, 1775). Further 3 adult males and 2 adult females of *P. encarpatus* from the same locality were kept and observed in captivity during 2 months in transparent plastic boxes 140x140x60 mm. Stoppered holes permitted insertion of prey without damaging webs and water was continually available from moist cotton rolls inserted through the hole from outside glass jar filled with water. A skewer with 3 pieces of thin pine bark (about 20x30x3mm) and some thin twigs were placed in each cage.

If in the text the expressions such as "usually" or "generally", "sometimes" or "occasionally", and "infrequently" or "rarely" were used, they indicate according to the convention frequencies of occurrence of about 80 per cent or more, 20-80 per cent and less than 20 per cent, respectively.

## RESULTS

### Nests

Both sexes of *Pseudicius encarpatus* build dense silky cocoon-like or tubular nests (chambers, retreats) for molting. The molting nests are situated in splits or crevices of the bark or under the loose bark, in the boxes in captivity often in edges or corners. The very similar cocoon-like chambers for oviposition are built by females only and are very dense and firm woven. In the nature they are always under loose bark. The female obviously stays with the eggs in the chamber up to the hatching of spiderlings. The nests for over-wintering are very similar to those for oviposition with the silk very dense and firm. Usually are several chambers found close together in an over-wintering aggregation (Fig. 1<sup>\*)</sup>). In spring I found some similar dense woven chambers with rests of dead males of *Pseudicius encarpatus*. Therefore I suppose that the males build such dense and firm chambers for their hibernation as well.

Sometimes, both sexes of *P. encarpatus* build less thick woven resting nests, roughly dome-shaped or tent-shaped (Fig. 2). These nests are usually used for one night only or for shorter periods of inactivity.

### Prey-catching "mesh"

Besides of nests the females of *Pseudicius encarpatus* build occasionally sparsely woven three-dimension silk structures which crudely resemble a web (the "mesh") of about 3x5 cm, which they use for prey-capture. These prey-catching webs are usually build in or over larger crevices in the bark, in captivity they were build in the corner of the cage or between thin twigs, which were a part of equipment of the box (Fig. 3). In contrary to the nests which were build in most instances at the first day after giving the spider into the cage already, the prey-catching webs were build some days later, not until the spider became familiar with its new environment. The silk of prey-catching webs is non-sticky or very poorly sticky only and it detains briefly insects landing on them.

### Predatory behaviour

The spider usually stays near the web (in the distance of about 2 cm) facing toward it or facing down. If the prey is detained for some period and does not move too vigorously, the spider approaches up to the distance of about 2 body lengths, fixates the prey and then sometimes leaps to catch it, but usually it walks instead of leaping up to the distance of about half body length and catches the prey by lunging at it (i. e. that the tarsi stay on the substrate as the spider moves forward). The spider holds the prey with its chelicerae and, after a short pause it pulls the insect from the silk and moves with the prey to feed on the wall of the cage, where it sits facing downwards.

The predatory behaviour away from the web is principally the same in both sexes of *Pseudicius encarpatus*. The spider may scan the environment from one place and then stalk the prey that comes near, or rarely it walks slowly straight line and stops periodically to look around and stalk the prey, if it is at close distance. The spiders began predatory sequences by turning to face insects that were active or sitting 20-30 mm away, then walk slowly toward them. If one or two body lengths away, the spider rarely leaps at the insect, however, usually it walks closer and lunges on the insect from about half body length away.

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\* Figs 1-3 will be found at the end of this issue, Plate 5.

The observed *Pseudicius encarpatus* usually took no notice to larger and fast moving insects. In captivity, the Housefly *Musca domestica* Linnaeus, 1758 was usually avoided, on the contrary the smaller and not so vigorous Lesser Housefly *Fannia canicularis* (Linnaeus, 1761) or more slowly moving, long-legged representatives of the dipteran families Dolichopodidae (mostly *Dolichopodus plumipes* (Scopoli, 1763)) and Culicidae (genera *Culex* Linnaeus and *Aedes* Meigen) were generally accepted as a prey.

#### DISCUSSION AND CONCLUSION

The comparative study of silk and web utilization and predatory behaviour in Salticidae has taken on heightened interest in last years, because it may help us to resolve some problems of salticid evolution. Recent studies concern before all the representatives of the "primitive" subfamilies Lyssomaninae and Spartaeinae and some fissident tropical salticids as *Euryattus* Thorell, 1881 and *Simaeutha* Thorell, 1881, which are also considered as "primitive".

The genus *Pseudicius* Simon, 1883, is not generally considered as primitive, although (as mentioned above) it exhibits some "primitive" behavioural characters. The affinities of *Pseudicius* to other salticid genera is not clear enough, it is sometimes ranked into the subfamily Heliophantinae, sometimes in Dendryphantinae.

Following results of our behavioural study of *Pseudicius encarpatus* may support the previous statements (Jackson 1986b) of the interesting behavioural aberrance of the genus *Pseudicius*.

1 *P. encarpatus* builds two types of nests: the densely woven cocoon-like or tubular nests for molting, oviposition and over-wintering, and less thick woven, dome-shaped or tent-shaped resting nests.

[Note: the tent-shaped nests resemble the similar structures build by representatives of Spartaeinae or *Euryattus*, which are considered to be "primitive" (Jackson 1985a, Jackson & Hallas 1986a, 1986b).]

2 Besides of nests females of *P. encarpatus* build sparsely woven three-dimensional structure of arrays, the "mesh", which they use for prey-capture. However, both sexes of *P. encarpatus* can catch motile insects as cursorial hunters, as well.

[Notice: web building is not expected by morphologically advanced salticids (Jackson 1986a) and spinning of webs is considered as plesiomorphic salticid behaviour (Jackson & Blest 1982).]

3 It removes the prey from the web before feeding.

[Notice: removing prey from the net before feeding has been observed in "primitive" salticid subfamily Lyssomaninae, too (Hallas & Jackson 1986).]

4 *P. encarpatus* rarely leaps during predation, it usually lunges at the prey from close distance instead of leaping on it.

[Notice: "Runners" which prefer lunging instead of leaping on its prey are considered to be more "primitive" than "advanced" "hoppers" (Crane 1949).]

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## Sixteen new species of *Leistus* from Asia (Coleoptera: Carabidae: Nebriini)

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**Taxonomy, descriptions, new records, Coleoptera, Carabidae, *Leistus*, Iran, Pakistan, India, Kashmir, Nepal, Sichuan, Yunnan, Gansu, Qinghai, Guizhou, Taiwan, Far East of Russia**

**Abstract.** Sixteen species of *Leistus* Froehlig, 1799 all belonging to the subgenus *Evanoleistus* Jedlička, 1967 are described as new and illustrated. *L. richteri* sp. n. from Kashmir and Pakistan, *L. heinzi* sp. n. from Gansu, *L. brachyctus* sp. n. from Yunnan and Guizhou, *L. deuseianus* sp. n., *L. jani* sp. n., *L. klarae* sp. n., *L. kucerai* sp. n. all from Yunnan, *L. burkhanianus* sp. n., *L. haeckeli* sp. n., *L. kalabi* sp. n., *L. kangdingensis* sp. n., *L. kangmashanensis* sp. n., *L. schakyi* sp. n., *L. shunmalingensis* sp. n., *L. yajiangensis* sp. n. all from Sichuan, and *L. yunnanensis* sp. n. from Taiwan. The new species are compared to species already known from this regions. In addition, new interesting records of the following species of *Leistus* are presented: *L. (E.) nivium* Andrewes, 1925 from Kashmir, *L. (E.) loebli* Perrault, 1985 from Nepal, *L. (E.) farkasi* Sotoky, 1994 from Qinghai, *L. (E.) nokuensis* Minowa, 1932 from Taiwan, *L. (Leistus) janae* Farkač & Platenko, 1992 from the Far East of Russia, *L. (Leistus) angulicollis* Fairmaire, 1886 from Yunnan and *L. (Leistus) lenkoranensis* Reitter, 1885 from Iran. Holotypes of *L. (E.) kuhani* Farkač, 1993, *L. (E.) krali* Farkač, 1993, *L. (Leistus) janae* Farkač & Platenko, 1992, as well as the lectotype of *L. (Leistus) angulicollis* Fairmaire, 1886 are illustrated.

As more material of the family Carabidae from the eastern part of the Palearctic region becomes recently available the number of new species of the genus *Leistus* Froehlig, 1799 is steadily growing. This is mainly due to the pronounced endemism of most of the montane species of this genus. Thanks to the works of Perrault (1980, 1985a, 1985b, 1986b, 1988, 1990a, 1991 and 1994) and Sotoky (1994 and paper in press), we have now good knowledge of the species of the genus *Leistus* from the mentioned area.

With the increasing number of known species of the subgenus *Evanoleistus* Jedlička, 1967 the problems concerning the subgeneric division of the genus *Leistus* become more and more apparent. The differences between the subgenera *Evanoleistus*, *Leistus* s. str. and *Neoleistus* Erwin, 1970 are diminishing.

In this paper, which is based on the study of numerous material and on a complete literature survey, sixteen species of the subgenus *Evanoleistus* are described as new.

I have used several indexes in the descriptions of the species, their list including their abbreviations used in the text, follows:

antennal index: length of antennomere 5 / length of antennomere 3 = IA

pronotal index: width / length of pronotum = IPw/l

pronotal index two: maximum width of pronotum / basal width of pronotum = IPm/b

elytral - pronotal index: combined width of elytra / width of pronotum = IE/P

elytral index: length / width of elytra = IE/lw



***Leistus (Evanoleistus) richteri* sp. n. (Figs. 1, 18, 19, 52<sup>\*)</sup>)**

*Leistus (Evanoleistus) nivium* Perrault, 1985b: 51.

**DESCRIPTION** (habitus of holotype as in Fig. 52). Body length 9.5 - 10.0 mm. Colour dark brownish-black. Mandibles, tibiae, tarsi and antennomeres 2 - 11 paler. Mandibles long with sharp apex. Eyes as usual.  $IA = 1.49$ . Gular setae situated on transverse carina.

**Pronotum** (Fig. 1). Marginal bead dilated at middle third; lateral margin sinuate in front of posterior angles; posterior angles rectangular; middle portion of front margin and basal area weakly punctate. Basal impressions not particularly distinct; posterior seta absent.  $IPw/l = 1.51$ ,  $IPm/b = 1.77$ .

**Elytra**. Oval, maximum width behind middle, striae finely punctate.  $IE/P = 1.32$ ,  $IEI/w = 1.61$ .

**Aedeagus** (Figs 18, 19). In dorsal view with lateral margins distinctly emarginate in front of securiform apex.

**AFFINITIES**. *Leistus richteri* sp. n. resembles in habitus *L. nivium* Andrewes, 1925, but it differs by the considerably longer, rectangular posterior angles of pronotum and by the dilated marginal bead of pronotum, which is evenly wide in *L. nivium* (Fig. 1, and Perrault 1985b). In addition, the lateral margins of the distal portion of the aedeagus are distinctly emarginate in front of the securiform apex in *L. richteri*, where as they are almost parallel-sided in *L. nivium*.

**HOLOTYPE** (9.4 mm) Male, labelled Pakistan, Kagai-Tal, Shogran env., 2400 - 3000 m, 28.-29.vii.1981, lgt. W. Heinz. In the collection J. Párkač, Praha.

**PARATYPES**. Female, same data as holotype; male and female, same locality as holotype, 2300 - 3000 m, 24.-25.vii.1982, lgt. Erber & Heinz; 2 females, labelled Kachemire, Shogran, 6.-8.viii.1978, 2500 m, lgt. A. Richter, female, labelled Indian, Kashmir, Daksun env., 2700 m, 28.vii. - 2.viii.1989, lgt. W. Heinz; female, labelled Pakistan, Lake Saiful, Moluk, 3050 m, 11.vii.1979, lgt. Wittmer, det. G. G. Perrault, 1981 as *Leistus nivium* Andrewes (see Perrault 1985a, b). In the collections of J. Párkač, Praha; Naturhistorisches Museum Basel; A. Richter, Kempton and W. Heinz, Schwanfeld.

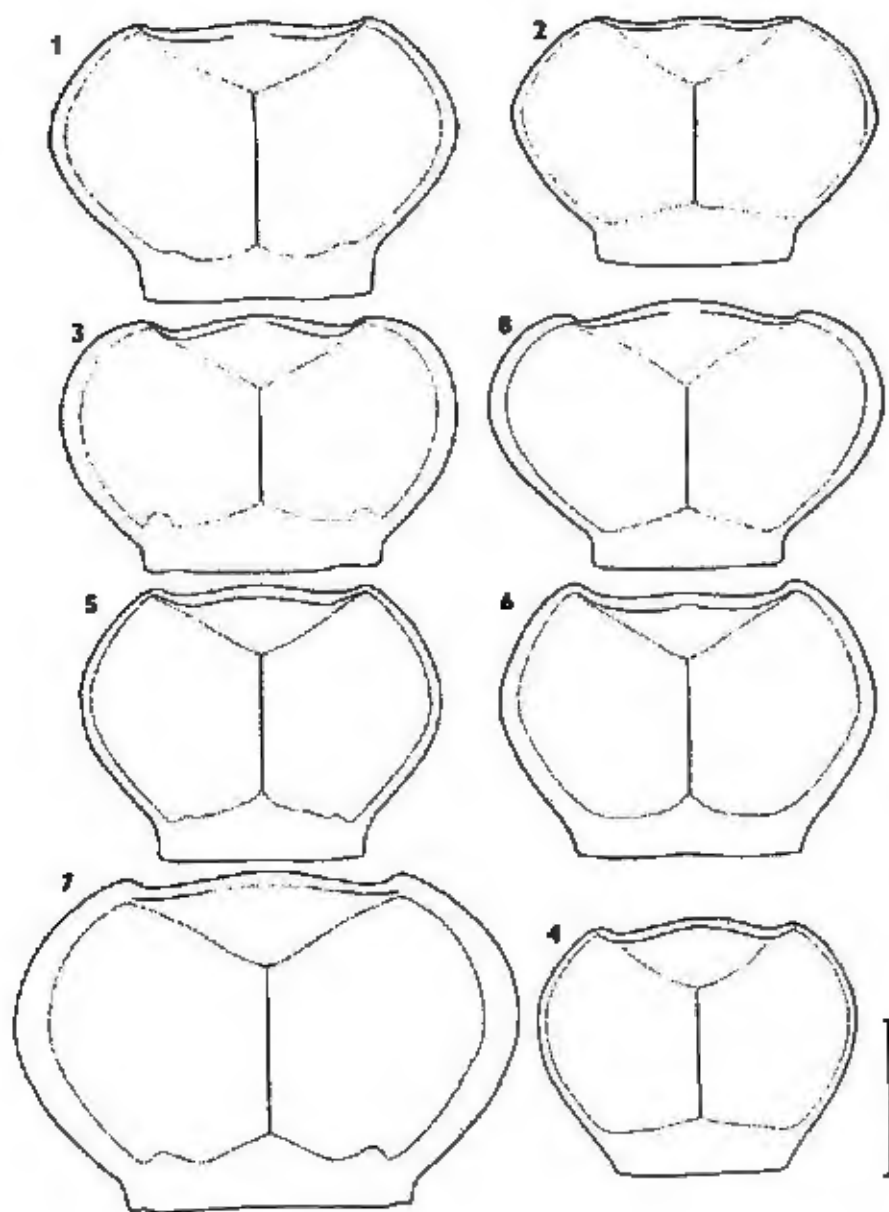
**ETYMOLOGY**. Patronymic, the new species is named in honour of my friend, Anton Richter, Kempton.

**COMMENT**. Perrault (1990a) presents a doubtful illustration of *Leistus nivium*, although a few years earlier (Perrault 1985a, b) he illustrates the pronotum and aedeagus from real specimens. It is also unclear, why Perrault, in 1981, named a female, labelled: Pakistan, Lake Saiful, Moluk, 3050 m, 11.vii.1979, lgt. Wittmer (in the collection of Naturhistorisches Museum, Basel) as *L. nivium*. After a careful comparison, I found this specimen not conspecific with the holotype (Natural History Museum, London) of *L. nivium*. It is included in the original series of *L. richteri*.

***Leistus (Evanoleistus) heinzi* sp. n. (Figs 2, 20, 21, 53)**

**DESCRIPTION** (habitus of holotype as in Fig. 51). Body length 7.3 - 8.2 mm. Colour dark brown, mandibles clypeus, maxillary appendages, tarsi and antennae paler. Eyes prominent. Gular setae situated on transverse carina. Mandibles as usual, with short, sharp apex.  $IA = 1.43 - 1.50$ .

<sup>\*)</sup> Figs 52-71 will be found at the end of this issue, Plate 1-4.



Figs 1-8. Pronotum of: 1 - *Leisus richteri* sp. n.; 2 - *L. hehzi* sp. n.; 3 - *L. brancuccii* sp. n.; 4 - *L. dauvelianus* sp. n.; 5 - *L. jani* sp. n.; 6 - *L. marae* sp. n.; 7 - *L. kucerai* sp. n.; 8 - *L. barkamensis* sp. n. Scale 1 mm.

**Pronotum** (Fig. 2). Lateral bead dilated around middle, lateral margin distinctly sinuate in front of posterior angles, posterior angles rectangular, middle portion of front margin and basal area coarsely punctate. Basal impressions distinct. Disc of pronotum very shiny, posterior seta absent.  $IPw/l = 1.48 - 1.50$ ,  $IPm/b = 1.84 - 1.92$ .

**Elytra**. Oval with prominent shoulders, maximum width behind middle. lateral bead narrow. lateral margin slightly sinuate apically, elytral striae regularly punctate, third interval with traces of 2-3 pores.  $IE/P = 1.24 - 1.30$ ,  $IE/w = 1.58 - 1.68$ .

**Aedeagus** (Figs 20, 21). Slightly dilated preapically, apex rounded.

**AFFINITIES** *Leistus heinzi* sp. n. resembles *L. shuamaluensis* sp. n., but it differs by the more distinctly sinuate lateral margin in front of the posterior angles of the pronotum, and by the differently shaped aedeagus (Figs 2, 14, 20, 21, 44, 45).

**HOLOTYPE** (8.2 mm). Male, labelled China, Gansu, passes ca 62 km W of Linxia, Da-li Jin Shan, 3600 m, 9-11 vii 1994. Jgt. W. Heinz. In the collection J. Farkaš, Praha.

**PARATYPES**. Male and female, same data as holotype. In the collection W. Heinz, Schwanfeld.

**ETYMOLOGY**. Patronymic, named in honour of my friend Walter Heinz, Schwanfeld, the collector of this new species.

### *Leistus (Evanoleistus) brancuccii* sp. n. (Figs 3, 22, 23, 54)

**DESCRIPTION** (habitus of holotype as in Fig. 54). Body length 8 - 10.0 mm, head and pronotum shiny black, elytra shiny, bronzed. Mandibles, tarsi and antennomeres 5 + 11 paler, brownish. Basal portion of mandibles wide, apex of mandibles sharp. Eyes prominent. Antennae long, slender.  $IA = 1.43$ . Gu. ar. setae situated not on transverse carina.

**Pronotum** (Fig. 3). With wide lateral bead, lateral margin sinuate in front of posterior angles, posterior angles rectangular, anterior and posterior area and lateral bead coarsely punctate, disc shiny; basal impressions distinct; posterior seta absent.  $IPw/l = 1.60 - 1.62$ ,  $IPm/b = 1.72$ .

**Elytra**. With prominent shoulders, lateral margin straight, punctuation of striae distinct, third interval with traces of four pores.  $IE/P = 1.25 - 1.32$ ,  $IE/w = 1.50 - 1.60$ .

**Aedeagus** (Figs 22, 23). In lateral view sharply curved, in dorsal view rounded apically, with distal portion asymmetrical.

**AFFINITIES**. Based on the asymmetrical portion of the aedeagus, *L. brancuccii* sp. n. belongs in the relationship of *L. taiwanensis* Perrault, 1986, *L. perreauti* Perrault, 1986, *L. baudinoti* Deuve, 1985 and *L. himalchutensis* Perrault, 1986. However, it differs from all markedly by the different shape of the pronotum (Fig. 3 and Deuve, 1985 and Perrault, 1986b) and by the bronze shine of the elytra.

**HOLOTYPE** (9.2 mm). Male, labelled Yunnan, 25°04'N - 101°55'E, Yapinglang, 1800-2000 m, 17-20 vi 1994. Jgt. Z. Čermák. In the collection J. Farkaš, Praha.

**PARATYPES**. Male, labelled Yunnan, 25°38'N - 100°09'E, Cangshan, 2800 m, 6 vi 1993. Jgt. Boim. female, labelled Yunnan, 24°57'N - 98°45'E, Gaoligong mts., 2200 - 2500 m, 8-16 vi 1995. Jgt. O. Semel. female, labelled CH-Guizhou, Fanjiangshan, Kuaichang, 20 km NW of Jiangkou, 27° - 3 vi 1995. Jgt. E. Jendek & O. Šauša. In the collections of the Naturhistorisches Museum, Basel and J. Farkaš, Praha.

**ETYMOLOGY**. Patronymic, the species is named in honour of Michel Brancucci, Naturhistorisches Museum, Basel.

*Leistus (Evanoleistus) deuveianus* sp. n. (Figs 4, 24, 25, 55)

DESCRIPTION (habitus of holotype in Fig. 55). Body length 8.3 - 9.5 mm. Colour pitchy brown, head darker. Mandibles, tarsi and maxillary appendages to the contrary paler. Mandibles long, with sharp, curved apex. Eyes prominent. Gular setae situated on transverse carina.  $LA = 1.40 \pm .50$ .

Pronotum (Fig. 4). Very narrow ( $IPw/l = 1.20 - 1.30$ ) with lateral margin evenly, very slightly sinuate in front of posterior angles, posterior angles obtusely angulate, lateral head evenly narrow, basal depressions shallow, indistinct, basal area finely, irregularly punctate, posterior seta absent.  $IPm/b = 1.80 \pm .93$ .

Elytra. Elongate-oval, with declining shoulders, maximum width behind middle, lateral head narrow, with lateral margin more distinct and slightly elevated in humeral area, punctuation of striae as usual.  $IE/P = 1.40 - 1.51$ ,  $IEI/w = 1.67 - 1.86$ .

Aedeagus (Figs 24, 25). In dorsal view narrowed into long, obtuse apical portion, in lateral view evenly curved up to apex.

AFFINITIES. *Leistus deuveianus* sp. n. differs from the habitually similar *L. gracilentus* Tschitscherine, 1903 by the in front of posterior angles more straight lateral margins of pronotum and by the more prominent shoulders (Figs 4, 24, 25, 55, and Perrault 1994). It differs from *L. perraulti* Sciaky, 1994 by the differently shaped distal portion of the aedeagus (Figs 24, 25, and Sciaky 1994). *L. deuveianus* differs from *L. jani* sp. n. and *L. klarae* sp. n. (see below), occurring also in the mountains of northern Yunnan by the differently shaped pronotum and aedeagus (Figs 4, 24, 25, 5, 26, 27, 6, 28, 29).

HOLOTYPE (8.7 mm). Male, labelled Yunnan, Haba Xue Shan, 4300 m, VIII, 1991, leg. T. Deuve. In the collection of the Muséum National d'Histoire naturelle, Paris.

PARATYPES. 2 males and 4 females, same data as holotype. In the collections J. Farkaš, Praha and in the Muséum National d'Histoire naturelle, Paris.

ETYMOLOGY. Patronymic, named in honour of Thierry Deuve, Muséum National d'Histoire naturelle, Paris, the collector of this new species.

*Leistus (Evanoleistus) jani* sp. n. (Figs 5, 26, 27, 56)

DESCRIPTION (habitus of holotype as in Fig. 56). Body length 9.4 mm (only holotype known).

Elytra pitchy brown, head black. Mandibles, tarsi, basal portions of antennomeres 1 - 4, and antennomeres 5 - 11 paler. Mandibles wide and long, with faint external sinuation. Head prominent. Antennae long and slender.  $LA = 1.33$ . Gular setae situated on transverse carina.

Pronotum (Fig. 5). With slightly prominent, obtuse anterior angles, lateral margin sinuate in front of posterior angles, posterior angles rectangular, lateral head and basal area punctate, middle portion of anterior margin roof-like elevated, middle line distinct, posterior seta absent.  $IPw/l = 1.30$ ,  $IPm/b = 1.66$ .

Elytra. Elongate-oval, maximum width around middle, lateral margin slightly elevated, more distinctly so at shoulders, punctuation of striae distinct.  $IE/P = 1.30$ ,  $IEI/w = 1.83$ .

Aedeagus (Figs 26, 27). In lateral view evenly curved, margins of distal portion parallel-sided, apex rounded.

Female unknown.

AFFINITIES. *Leistus jani* sp. n. is in its habitus similar to *L. bohemosum* Sciaky, 1994 from Sichuan, but it differs by the shape of the aedeagus (Figs 26, 27 and Sciaky, 1994). It differs from *L. klarae*

sp. n., that occurs at the same locality, by the narrower pronotum (Figs 5, 6) and by the differently shaped distal portion of the aedeagus (Figs 26 - 29).

**HOLOTYPE.** Male, labelled: N. Yunnan, 27 49N 99 34E, mts. 15 km W of Zhongdian, 4200 - 4700 m, 23 vi. 1994. 1st. J. Farkaš & D. Král. In the collection J. Farkaš, Praha.

**ETYMOLOGY.** Patronymic, dedicated to my son Jan.

**COLLECTION CIRCUMSTANCES.** The holotype was taken together with *L. klarae* sp. n. at the elevation of about 4500 m from under bark of coniferous trees, lying on the ground.

*Leistus (Evanoleistus) klarae* sp. n. (Figs 6, 28, 29, 57)

**DESCRIPTION** (habitus of holotype as in Fig. 57). Body length 8.8 - 9.3 mm. Colour shiny brown-black; head darker; tarsi, antennomeres 2 - 11, mandibles and maxillary appendages to the contrary paler. Head larger than usual, mandibles wide, shortly acuminate, with faint external sinuation. Eyes larger than usual. Gular setae situated on small transverse carina.  $IA = 1.25 - 1.33$ .

**Pronotum** (Fig. 6). Lateral bead dilated toward posterior angles; lateral margin only vaguely sinuate in front of obtusely angulate posterior angles, lateral bead and basal area irregularly, weakly punctate; middle line distinct. Posterior seta absent.  $IPw/l = 1.38 - 1.46$ ,  $IPm/b = 1.69 - 1.79$ .

**Elytra.** Oval, maximum width at middle portion; lateral margin slightly elevated at shoulders, punctuation of striae distinct.  $IE/P = 1.25 - 1.33$ ,  $IEl/w = 1.71 - 1.80$ .

**Aedeagus** (Figs 28, 29). Narrowed into obtuse apex distally.

**AFFINITIES.** *Leistus klarae* sp. n. differs from *L. bohemosum* Sciaky, 1994 from Sichuan by the shape of the aedeagus (Figs 28, 29, and Sciaky, 1994). It differs from *L. jani* sp. n., that lives at the same locality, by the different shape of the pronotum (Figs 5, 6), and by the differently shaped distal portion of the aedeagus (Figs 26 - 29).

**HOLOTYPE** (9.0 mm). Male, labelled: N. Yunnan, 27 49N 99 34E, mts. 15 km W of Zhongdian, 4200 - 4700 m, 23 vi. 1994. 1st. J. Farkaš & D. Král. In the collection J. Farkaš, Praha.

**PARATYPES.** 4 males and 1 female, same data as holotype. In the collections J. Farkaš, Praha, and R. Sciaky, Milano.

**ETYMOLOGY.** Patronymic, dedicated to my daughter Klára.

**COLLECTION CIRCUMSTANCES.** The original series was taken, together with *L. jani* sp. n., at the elevation of about 4500 m, from under bark of coniferous trees lying on the ground.

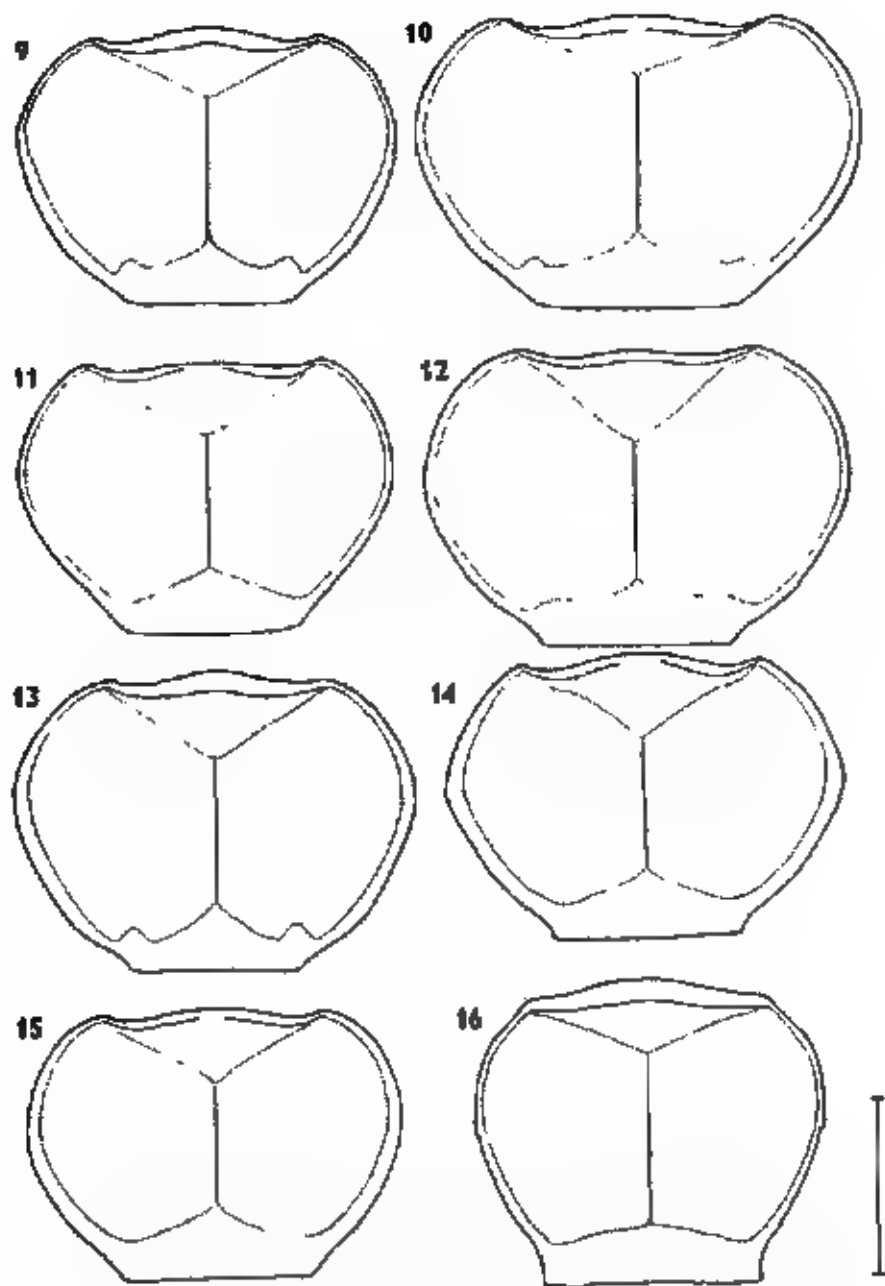
*Leistus (Evanoleistus) kucerai* sp. n. (Figs 7, 30, 31, 58)

**DESCRIPTION** (habitus of holotype as in Fig. 58). Body length 10.0 - 11.1 mm. Colour black, antennae, mandibles and tarsi brownish. Head of usual size and shape with irregular, rugose impressions above eyes. Apex mandibles sharp. Gular setae situated on small transverse carina. Antennae long and slender.  $IA = 1.47 - 1.60$ .

**Pronotum** (Fig. 7). Big distinctive, lateral bead wide, flat, widened toward posterior angles, posterior angles sharply rectangular; basal impressions distinct, basal depressions coarsely punctate; posterior seta absent.  $IPw/l = 1.48 - 1.66$ ,  $IPm/b = 1.75 - 1.94$ .

**Elytra.** Broadly oval, maximum width at about first third, shoulders rounded; lateral bead distinct; punctuation of striae distinct.  $IE/P = 1.07 - 1.18$ ,  $IEl/w = 1.70 - 1.87$ .

**Aedeagus** (Figs 30, 31). In lateral view with straight, not curved apex.



Figs 9-16 Pronotum of: 9 - *L. haeckeli* sp. n., 10 - *L. kalabi* sp. n., 11 - *L. kangdunensis* sp. n., 12 - *L. langmuirianus* sp. n., 13 - *L. tschakyr* sp. n., 14 - *L. shuamaluho* sp. n., 15 - *L. yapiangensis* sp. n., 16 - *L. amatanai* sp. n. Scale 1 mm.

**AFFINITIES** *Leistus kucerai* sp. n. resembles by its habitus *L. kubani* Farkač, 1993 and *L. yunnanus* Banninger, 1925, but differs from both markedly by the shape of the distal portion of the aedeagus, which is curved in lateral view in *L. kubani* and straight in *L. kucerai* (Figs 40, 31 and see also Farkač 1993). The distal portion of the aedeagus is asymmetrical in *L. yunnanus* (Fig. in Perrault 1985a).

**HOLOTYPE** (11.0 mm): Male, labelled China, Yunnan, Zhongdian, 16.21 vi 1994, leg. E. Kučera. In the collection J. Farkač, Praha.

**PARATYPES** 3 males and female: same data as holotype, 4 males, same data as holotype, dated 17 vi – 19 vi 1995. In the collections J. Farkač, Praha; P. Bulirsch, Lovosice; E. Kučera, Soběslav and R. Strásky, Milano.

**ETYMOLOGY** Patronymic, named in honour of Emil Kučera, the collector of this new species.

***Leistus (Evanoleistus) barkamensis* sp. n. (Figs 8, 32, 33, 59)**

**DESCRIPTION** (habitus of holotype as in Fig. 59). Body length 8.9 – 9.1 mm (only two males known). Colour black with slight brownish tint, surface shiny. Mandibles, maxillary appendages, tarsi and antennomeres 2 – 11 paler, yellowish-brown. Eyes prominent. Gular setae situated on transverse carina.  $LA = 1.45 - 1.50$ .

**Pronotum** (Fig. 8). With wide lateral bead, narrowed in front of posterior angles, lateral margin distinctly sinuate in front of posterior angles, posterior angles rectangular. pronotal base narrow, middle portion at anterior margin and basal area coarsely punctate, middle of pronotum shiny, posterior seta absent.  $IPw/l = 1.47 - 1.49$ ,  $IPm/b = 2.04 - 2.12$ .

**Elytra**. Oval, with evenly rounded shoulders, maximum width behind middle, lateral bead narrow, punctate, punctuation of striae distinct, coarse.  $IE/P = 1.21 - 1.27$ ,  $IEl/w = 1.64 - 1.66$ .

**Aedeagus** (Figs 32, 33). In dorsal view with obtuse, rounded apex.

**Female** unknown.

**AFFINITIES** *Leistus barkamensis* sp. n. is in habitus similar to *L. shuanaluko* sp. n., but it by the different shape of pronotum (Figs 8, 14) and by the considerably different shape of the distal portion of the aedeagus (32, 33, 44, 45).

**HOLOTYPE** (9.1 mm): Male, labelled China, Sichuan, Barkam S.-environs, 31°53'N 102°12'E, 2900 – 3700 m, 22 vi 1994, leg. K. & B. Březina. In the collection J. Farkač, Praha.

**PARATYPE** Male: same data as holotype, leg. M. Hackel. In the collection J. Farkač, Praha.

**ETYMOLOGY** The specific name is derived from the name of the village Barkam, in the vicinity of which the new species was found.

**COLLECTIONS CIRCUMSTANCES** The original specimens were collected in a mixed broadleaved and coniferous forest.

***Leistus (Evanoleistus) haeckeh* sp. n. (Figs 9, 34, 35, 60)**

**DESCRIPTION** (habitus of holotype as in Fig. 60). Body length 8.5 – 9.6 mm. Colour shiny black, mandibles, maxillary appendages, tarsi, basal parts of antennomeres 2 – 4, and antennomeres 5 (1. pair). Mandibles long with sharp apex, eyes prominent. Gular setae situated on small transverse carina. Antennae long and slender.  $LA = 1.58 - 1.68$ .

**Pronotum** (Fig. 9). Lateral bead from seta at middle portion of lateral margin dilated toward posterior angles, arc of lateral pronotal margin uneven, almost straight in front of posterior angles, posterior angles obtusely angulate, basal area coarsely punctate, posterior seta absent.  $IPw/l = 1.28 - 1.45$ ,  $IPm/b = 2.09 - 2.24$ .



Elytra. Oval, maximum width behind middle, punctuation of striae distinct, lateral bead of elytra more distinctive at shoulders, 3 - 6 setiferous punctures in third interval IE/P = 1.27 - 1.36, IPW/w = 1.66 - 1.74.

Aedeagus (Figs 34, 35). In lateral view thickened before apex, apex itself obtuse.

AFFINITIES. *Leistus haeckeli* sp. n. is in the habitus similar to *L. sichuanus* Szuky, 1994, but it differs by the in basal portion narrower pronotum (*L. haeckeli* IPm/b = 2.09 - 2.24, *L. sichuanus* IPm/b = 1.93). It differs from the habitually similar *L. sruskyi* sp. n., occurring in the same range, by the different shape of the distal portion of the aedeagus (Figs 34, 35, 42, 43).

HOLOTYPE (♀ 0 mm) Male labelled China, W Sichuan, Gongga Shan mts, Moxi env. vi.1993, lgt. M. Häckel. In the collection J. Farkaš, Praha.

PARATYPES. Female: same data as holotype. female, same data as holotype. lgt. V. Beneš, female, labelled China, C Sichuan (Kangding), Gongga Shan massive, 29°49'N 102°03'E, ca 25 km NNW of Moxi village, 2900 m, 30.v.1993. lgt. B. Březina, male, labelled China, Sichuan, Gongga Shan, above Camp 3, 3300 - 3350 m, 23.vii.1994, lgt. A. Smetana, 3 males and female, labelled China, Sichuan, Gongga Shan, above Camp 3, 3300 m, 25-27.vii.1994, lgt. V. Beneš, 8 males, labelled W Sichuan, Gonggashan, Hailuoguo, 29°35'N 102°06'E, 2900 - 3200 m, 3.6.vii.1994, lgt. J. Farkaš & D. Král. In the collections J. Farkaš, Praha, V. Beneš, Ústí n. L., M. Dvořák, Praha, M. Häckel, Ústí n. L., Naturhistorisches Museum, Basel, Muséum National d'Histoire naturelle, Paris and R. Sciaky, Milano.

ETYMOLOGY. Patronymic named in honour of my friend Martin Häckel, the first collector of this new species.

COLLECTION CIRCUMSTANCES. Specimens were collected in a montane, mixed broadleaved and coniferous forest.

### *Leistus (Evanoleistus) kalabi* sp. n. (Figs 10, 36, 37, 61)

DESCRIPTION (habitus of holotype as in Fig. 61). Body length 9.0 - 10.0 mm. Colour brown to piceous-brown, surface shiny. Legs, antennae, mandibles and maxillary appendages paler. Eyes prominent. Gular setae situated on transverse carina. LA = 1.34 - 1.47.

Pronotum (Fig. 10). Heart-shaped, with narrow basal portion, lateral margins evenly rounded, not sinuate before posterior angles, basal area markedly lowered, coarsely punctate, lateral bead narrow, not dilated toward posterior angles, posterior seta absent. IPw/l = 1.42 - 1.51, IPm/b = 2.01 - 2.17.

Elytra. Oval, maximum width behind middle; shoulders not prominent, evenly rounded, punctuation of striae distinct, elytral apex evenly curved. IE/P = 1.32 - 1.41, IEI/w = 1.57 - 1.65.

Aedeagus (Figs 36, 37). Evenly narrowed into narrowly arcuate apex.

AFFINITIES. *Leistus kalabi* sp. n. resembles *L. deuvei* Perrault, 1994, but it differs by the differently shaped aedeagus (Figs 36, 37 and Perrault 1994). *Leistus kalabi* differs from *L. yajiangensis* sp. n. by the differently shaped distal portion of the aedeagus (Figs 36, 37, 46, 47).

HOLOTYPE (♀ 0 mm) Male labelled China, SW Sichuan, road Litang-Sumdo, pass 60 km SSW of Litang, 4602 m, 4-7.vii.1994. In the collection J. Farkaš, Praha.

PARATYPES. 13 males and 21 females, same data as holotype. 9 males and 8 females, labelled China, W Sichuan, road Litang Batang, pass 70 km WNW of Litang, 4675 m, 21-22.vii.1994, 3 males and female, labelled China, SW Sichuan, road Daocheng-Gaqaq, pass 35 km S of Daocheng, 3500 m, 15.18.vii.1994. In the collections J. Farkaš, Praha, I. Bělousov, Saint-Petersbourg, P. Bulirsch, Lovonice, Canadian National Collection, Ottawa, M. Dvořák, Praha, M. Häckel, Ústí n. L., W. Heinz, Schwandfeld, I. Kabak, Almaty, J. Kádár, Jinačovice, P. Morvan, Brezih, Muséum d'Histoire naturelle, Genève, Muséum National d'Histoire naturelle, Paris, Naturhistorisches Museum, Basel, A. Plutenko, Artem, R. Sciaky, Milano, Taiwan Agricultural Research Institute, Wufeng and D. Wrase, Berlin.

**ETYMOLOGY.** Patronymic, named in honour of my friend, the Moravian carabidologist Jaroslav Kaláb, Jinačovice.

**COLLECTION CIRCUMSTANCES.** All specimens of the original series were taken in the alpine zone.

*Leistus (Evanoleistus) kangdingensis* sp. n. (11, 38, 39, 62)

**DESCRIPTION** (habitus of holotype as in Fig. 62). Body length 7.4 - 8.0 mm. Colour black, surface shiny. Mandibles, maxillary appendages, antennae and tarsi paler. Eyes prominent. Gular setae situated on transverse carina.  $IA = 1.55 - 1.57$ .

**Pronotum** (Fig. 11). Lateral bead narrow, lateral margin evenly rounded, straight in front of posterior angles, posterior angles obtusely angulate, basal area finely and sparsely punctate, posterior seta absent.  $IPw/l = 1.44 - 1.47$ ,  $IPm/b = 2.00 - 2.09$ .

**Elytra.** Ova, maximum width behind middle, shoulders indistinct, lateral bead narrow, striae finely punctate, both striae and punctuation becoming obsolete in apical portion.  $IE/P = 1.24 - 1.31$ ,  $IEU/w = 1.56 - 1.68$ .

**Aedeagus** (Figs 38, 39). In dorsal view relatively wide, narrowed into short apex.

Female unknown.

**AFFINITIES.** *Leistus kangdingensis* sp. n. is in habitus similar to *L. saueri* Sciaky, 1994, but it differs by the differently shaped aedeagus (Figs 38, 39 and Sciaky, 1994).

**HOLOTYPE** (8.0 mm), male, labelled China, W Sichuan, road Kangding-Xinduqiao, peak 16 km W of Kangding, 4290 m, 3.viii. 1994. In the collection J. Párkač, Praha.

**PARATYPE** Male, same data as holotype male, labelled China, W Sichuan, 30 km W of Kangding, 5000 m, 26.vii. 1994. In the collection J. Párkač, Praha.

**ETYMOLOGY.** The specific name is derived from the name of the town of Kangding, in the vicinity of which the new species was found.

**COLLECTION CIRCUMSTANCES.** All specimens were taken in the alpine zone.

*Leistus (Evanoleistus) langmusianus* sp. n. (Figs 12, 40, 41, 63)

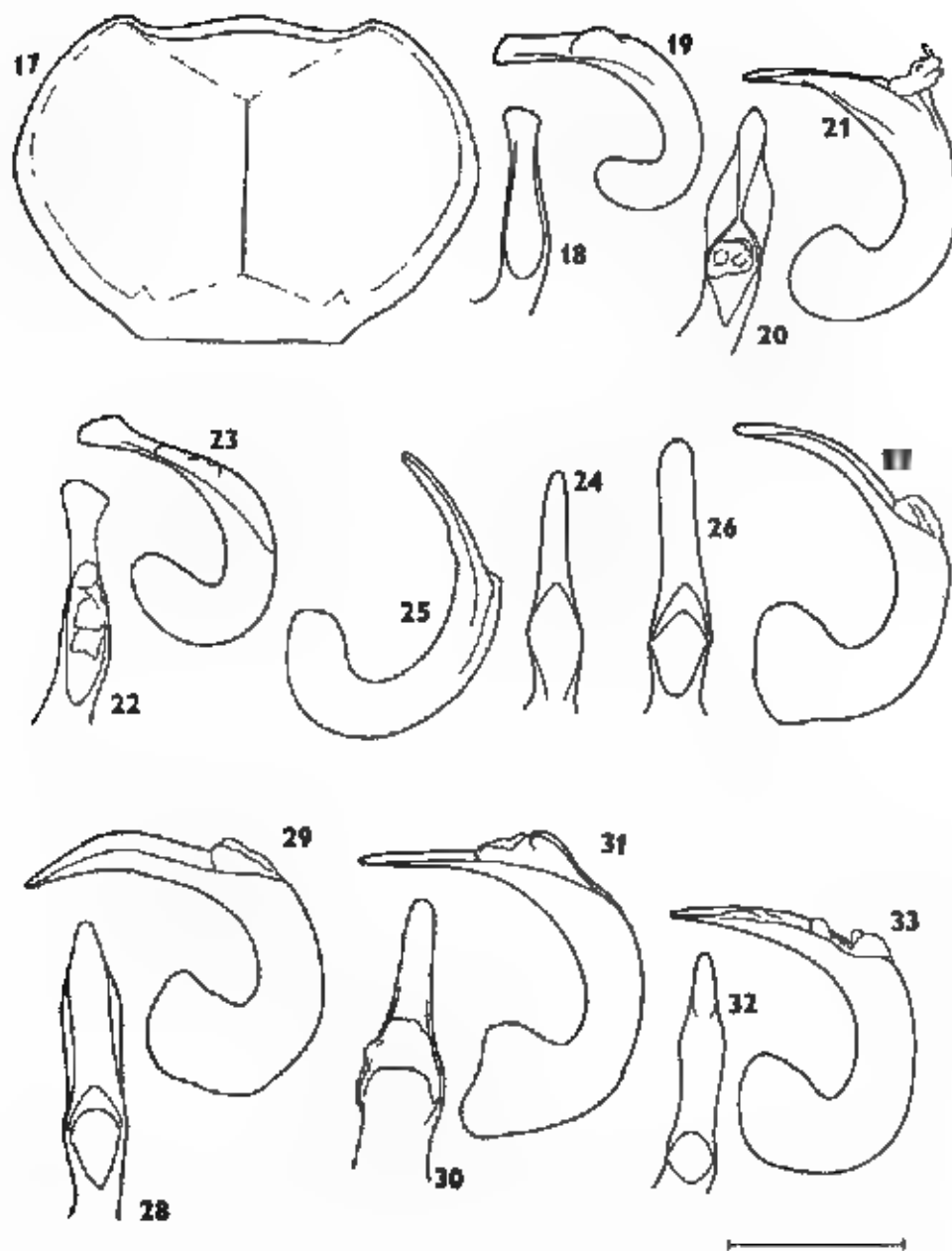
**DESCRIPTION** (habitus of holotype as in Fig. 63). Body length 9.0 - 9.8 mm. Colour black, surface shiny. Mandibles, maxillary appendages, basal portions of antennomeres 2 - 4 and antennomeres 5 - 11 paler. Eyes prominent. Gular setae situated on transverse carina.  $IA = 1.45 - 1.52$ .

**Pronotum** (Fig. 12). Lateral bead from setiferous puncture, situated around middle, inconspicuously dilated toward posterior angles, lateral margin slightly sinuate in front of posterior angles, posterior angles obtusely angulate, middle portion of anterior margin and basal area coarsely punctate; pronotal disc convex, shiny, posterior seta absent.  $IPw/l = 1.41 - 1.46$ ,  $IPm/b = 2.28 - 2.30$ .

**Elytra.** Oval, maximum width behind middle; shoulders evenly rounded, weakly distinct, lateral bead narrow, more distinct at shoulders, lateral margin slightly sinuate before apex, punctuation of striae distinct, apex more extended in female.  $IE/P = 1.23 - 1.30$ ,  $IEU/w = 1.52 - 1.67$ .

**Aedeagus** (Figs 40, 41). Robust, width short, obtuse apex.

**AFFINITIES.** *Leistus langmusianus* sp. n. resembles in habitus *L. gansuensis* Sciaky (in press), but differs by the differently shaped distal portion of the aedeagus and by the less oval elytra (Figs 40, 41, 63 and Sciaky in press).



Figs 17-33. Proctotrus of 17 - *L. angulicollis* Furman, 1886, aedeagus in dorsal and lateral view of 18, 19 - *L. nictens* sp. n. 20, 21 - *L. heinz* sp. n. 22, 23 - *L. brancuccii* sp. n. 23, 25 - *L. deuveianus* sp. n., 26, 27 - *L. jam* sp. n. 28, 29 - *L. kiarai* sp. n. 30, 31 - *L. lucera* sp. n., 32, 33 - *L. barkamensis* sp. n. Scale 1 mm.

**HOLOTYPE** (9.0 mm) Male, labelled China, Sichuan, Langmuo mts 3500–3600 m, 13–14.vii.1994, lgt. W. Hrená, in the collection J. Farkač, Praha.  
**PARATYPE** Female, labelled China, Sichuan, Langmuo, 3600 m, 4.vii.1994, lgt. A. Smetana (C.S.). In the collection J. Farkač, Praha.

**ETYMOLOGY** The specific name is derived from the name of the village of Langmuo, in the vicinity of which the new species was found.

*Leistus (Evanoleistus) sciakyi* sp. n. (Figs 13, 42, 43, 64)

**DESCRIPTION** (habitus of holotype as in Fig. 64) Body length 8.5–9.5 mm. Colour shiny black; mandibles, maxillary appendages, tarsi, basal portions of antennomeres 2–4 and antennomeres 5–11 paler, brownish. Mandibles long, with sharp apex, eyes prominent. Gular setae situated on small transverse carina.  $IA = 1.48 - 1.68$ .

**Pronotum** (Fig. 13) Lateral bead from setiferous puncture, situated around middle, slightly dilated toward posterior angles, arc of lateral margin uneven, slightly sinuate in front of posterior angles, posterior angles obtusely angulate, basal area punctate, posterior seta absent.  $IPw/l = 1.36 - 1.45$ ,  $IPm/b = 2.15 - 2.29$ .

**Elytra** Oval, maximum width behind middle, punctuation of striae distinct, 4–5 setiferous punctures in third interval.  $IE/P = 1.27 - 1.34$ ,  $IE/lw = 1.67 - 1.71$ .

**Aedeagus** (Figs 42, 43) In lateral view evenly narrowed toward narrowly arcuate apex.

**AFFINITIES** *Leistus sciakyi* sp. n. resembles in habitus *L. haeckeli* sp. n., occurring in the same mountain range, but it differs by the differently shaped distal portion of the aedeagus (Figs 34, 35, 42, 43). It differs from *L. sichuanus* Sciaky, 1994 by the narrower pronotum (Figs 13, 64, and Sciaky 1994).

**HOLOTYPE** (9.1 mm) Male, labelled W. Sichuan, 29°50'N 102°09'E Gongga Shan mts, NE slope, 2500–3500 m, 8.vii.1994, lgt. J. Farkač & D. Král, in the collection J. Farkač, Praha.

**PARATYPES** 31 males and 24 females, the same data as holotype. In the collections J. Farkač, Praha; T. Bělousov, Saint Petersburg; P. Bultsch, Lovosice; Canadian National Museum, Ottawa; M. Dvorník, Praha; M. Farkas, Praha; M. Hacker, Uetikon am See; W. Hrená, Schwanfeld; I. Kabak, Aqmaly; P. Morvan, Brezili; Muséum d'Histoire naturelle, Genève; Muséum National d'Histoire naturelle, Paris; National Museum, Praha; Naturhistorisches Museum, Basel; A. Plutenko, Artem; R. Sciaky, Milano; Taiwan Agricultural Research Institute, Wufeng and D. Wrase, Berlin.

**ETYMOLOGY** Patronymic, named in honour of my colleague and friend, Riccardo Sciaky, the renowned carabidologist from Milano.

**COLLECTION CIRCUMSTANCES** All specimens were taken at about 3200 m of elevation, running during the night on exposed dirt slopes of the trail in a montane mixed forest.

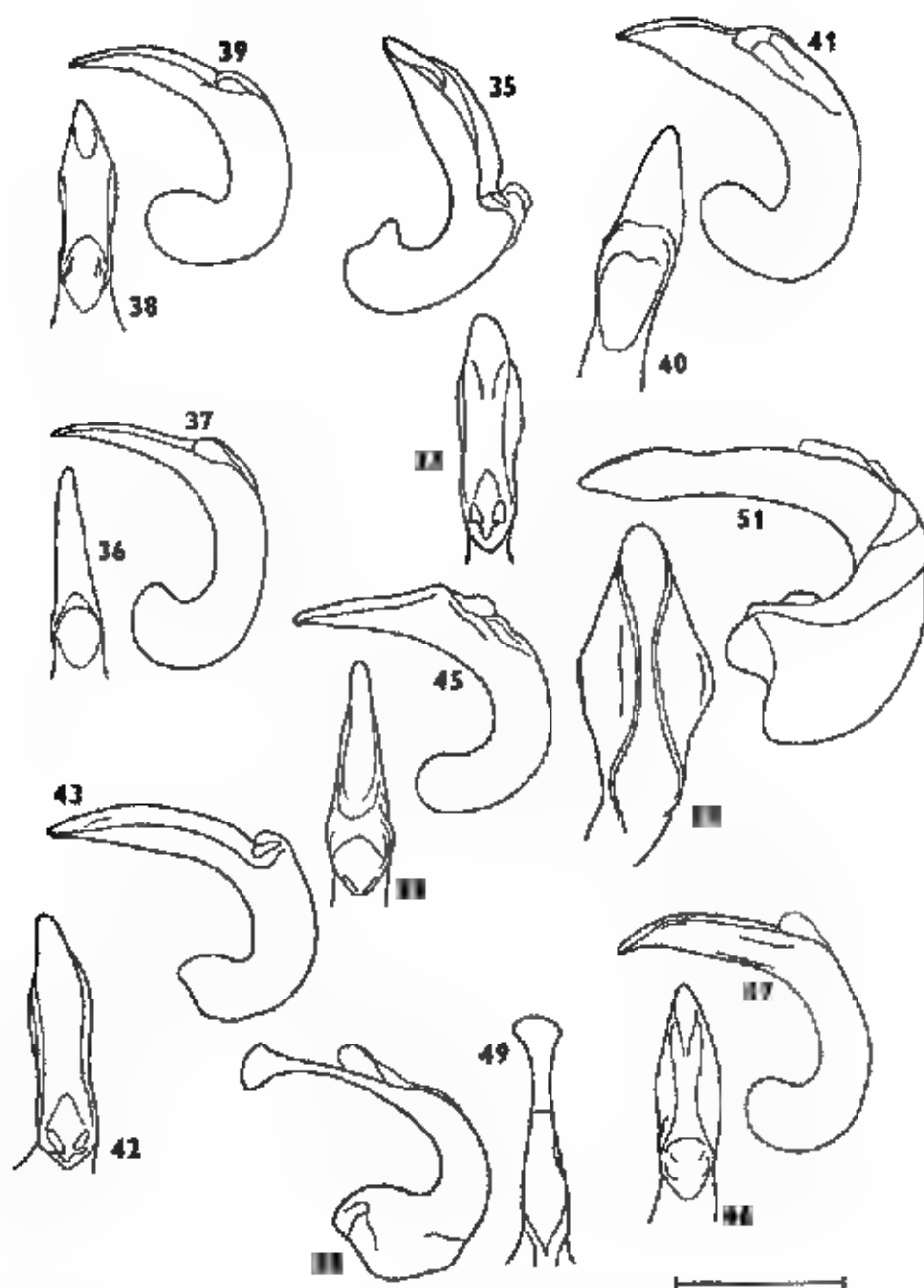
*Leistus (Evanoleistus) shuamoluko* sp. n. (Figs 14, 44, 45, 65)

**DESCRIPTION** (habitus of holotype as in Fig. 65) Body length 8.7 mm (only holotype known). Colour black, surface shiny. Tarsi, mandibles, maxillary appendages and antennomeres 4–11 paler. Eyes prominent. Gular setae situated on transverse carina.  $IA = 1.50$ .

**Pronotum** (Fig. 14) With conspicuous lateral margin markedly angulate in middle portion and slightly sinuate in front of posterior angles, lateral bead dilated at angular portion of lateral margin, basal area coarsely punctate, posterior seta absent.  $IPw/l = 1.43$ ,  $IPm/b = 2.10$ .

**Elytra** Oval, distinctly widest behind middle, lateral bead narrow, shoulders not pronounced, evenly rounded, punctuation of striae coarse.  $IE/P = 1.30$ ,  $IE/lw = 1.71$ .

**Aedeagus** (Figs 44, 45) In dorsal view narrowed into obtuse, rounded apex.



Figs 34-51 Aedeagus in dorsal and lateral view of 34, 35 - *L. haekelii* sp. n., 36, 37 - *L. kalabri* sp. n., 38, 39 - *L. kangdingensis* sp. n., 40, 41 - *L. longimuratus* sp. n., 42, 43 - *L. neokyi* sp. n., 44, 45 - *L. shuaimoluo* sp. n., 46, 47 - *L. yayuogensis* sp. n., 48, 49 - *L. smetanai* sp. n., 50, 51 - *L. angulicollis* Fairmaire, 1886. Scale 1 mm.

Female unknown

**AFFINITIES.** *Leistus shuamaluko* sp. n. resembles in general habitus *L. barkamensis* sp. n., but it differs by the different shape of the pronotum (Figs 8, 14) and by the markedly different distal portion of the aedeagus (Figs 32, 33, 44, 45).

**HOLOTYPE.** Male, labelled: China, Sichuan, Shuamaluko, vi.1994, leg. M. Häckel. In the collection J. Farkas, Praha.

**ETYMOLOGY.** The specific name is the name of the village of Shuamaluko, the type locality, noun in apposition.

*Leistus (Evanoleistus) yajiangensis* sp. n. (Figs 15, 46, 47, 66)

**DESCRIPTION** (habitus of holotype as in Fig. 66). Body length 8.3 mm (only holotype known). Colour brownish-black, surface shiny. Legs, antennae, mandibles and maxillary appendages paler. Eyes prominent. Gular setae situated on transverse carina,  $IA = 1.56$ .

**Pronotum** (Fig. 15). Lateral margin evenly rounded, lateral bead slightly dilated toward posterior angles, lateral margin in front of posterior angles almost straight, with traces of sinuation; posterior angles obtusely angulate, basal area sparsely punctate, posterior seta absent.  $IPw/l = 1.45$ ,  $IPm/b = 1.98$ .

**Elytra.** Oval, maximum width behind middle, shoulders evenly rounded, without humeral tooth. Lateral bead narrow, gradually disappearing before apex, punctuation of elytral striae distinct, third interval with traces of three larger pores.  $IE/P = 1.30$ ,  $IEl/w = 1.70$ .

**Aedeagus** (Figs 46, 47). In lateral view more pronouncedly curved before apex, in dorsal view distal portion slightly dilated, with distinct median groove, apex narrowly rounded.

Female unknown.

**AFFINITIES.** *Leistus yajiangensis* sp. n. resembles in general habitus *L. kalabi* sp. n. and *L. kangdugensis* sp. n., but it differs from both by the shape of pronotum and of the aedeagus (Figs 10, 11, 15, 36 - 39, 46, 47, 61, 62, 66).

**HOLOTYPE.** Male, labelled: China, W. Sichuan, road Litang-Yajiang, pass 20 km W of Yajiang, 3200 - 3500 m, 23.-25.vii.1994. In the collection J. Farkas, Praha.

**ETYMOLOGY.** The specific name is derived from the name of the village Yajiang, the type locality.

*Leistus (Evanoleistus) smetanai* sp. n. (Figs 16, 48, 49, 67)

**DESCRIPTION** (habitus of holotype as in Fig. 67). Body length 9.0 - 9.6 mm. Colour shiny brown, head darker. Mandibles, maxillary appendages, clypeus, antennomeres 2-11, and front tarsi paler, femora on contrary darkened. Mandibles markedly long, with not much curved but sharp apex. Eyes usual. Gular setae situated on transverse carina,  $IA = 1.68 - 1.70$ .

**Pronotum** (Fig. 16). Almost as long as wide,  $IPw/l = 1.15 - 1.18$ . Lateral bead narrow, vaguely dilated toward posterior angles, lateral margin vaguely angulate in middle portion, with setiferous puncture at angle, slightly sinuate before posterior angles, posterior angles almost rectangular, posterior seta absent.  $IPm/b = 1.61 - 1.69$ .

**Elytra.** Without shoulders, maximum width behind second third, punctuation of striae fine.  $IE/P = 1.47 - 1.52$ ,  $IEl/w = 1.57 - 1.82$ .

**Aedeagus** (Figs 48, 49). Asymmetrically dilated distally.

**AFFINITIES.** Based on the asymmetrically dilated distal portion of the aedeagus *L. smetana* sp. n. belongs near the species *L. chaictes* Andrewes, 1936, *L. kunatai* Habu, 1973, *L. heinigeri* Morvan, 1991 and *L. rolex* Morvan, 1991. It differs from all of them by the markedly different shape of the pronotum, as well as by the general habitus, resembling that of the central Asian species around *L. juldusanus* Reitter, 1913 (Figs 16, 67 and Perrault 1985b, Morvan 1991 and Shilenkov & Kabak, 1994).

**HOLOTYPE** (9.6 mm) Male, labelled: Taiwan, Taichung, Hsuehshan, above Shan-Lin-Cieu Hut, 3200 m, 8 v 1991, lgt. A. Smetana (T72) in the collection J. Farkaš, Praha.

**PARATYPES** 2 males, same data as holotype, 1 labelled 8.-10 v 1991, (T70) and 1 labelled 7 v 1991, (T69). In the collections of the Taiwan Agricultural Research Institute, Wufeng, and the Canadian National Collection, Ottawa.

**ETYMOLOGY.** Patronymic, named in honour of my friend, the renowned entomologist, Aleš Smetana, Ottawa, who corrected this new species.

#### *Leistus* (s. str.) *janae* Farkaš & Plutenko, 1992 (Fig. 70)

*Leistus* (s. str.) *janae* Farkaš & Plutenko, 1992: 161-162.

**NEW RECORD.** I have examined three specimens, labelled: E. Russia, S. Sikhote Alin Mts., Mt. Oblachnaya, 1700 m, vi 1994, lgt. A. Plutenko: the type locality.

This species was previously known only from the original nine specimens (Farkaš & Plutenko 1992). Compared with the holotype in collection J. Farkaš, Praha.

#### *Leistus* (s. str.) *lenkoranus* Reitter, 1885

*Leistus lenkoranus* Reitter, 1885: 213-219.

*Leistus lenkoranus* Morvan, 1977: 22-23, 40-42.

*Leistus* (s. str.) *lenkoranus* Perrault, 1988: 48-50; 1986a: 60; 1990b: 204 = *Leistus deliae* Morvan, 1977: 22-23, 40-42 (syn. by Perrault, 1990b: 204).

**NEW RECORD.** Male, labelled: Iran, Assalam-Hero-abadi, 1800 - 2350 m, 1. v 1970, lgt. Wüerner & Bothner: det. W. Heinz, 1970 as *L. fulvus* Chaudoir, 1846 (unpubl.).

Compared with the lectotype in collection Muséum d'Histoire naturelle, Paris.

#### *Leistus* (s. str.) *angulicollis* Fairmaire, 1886 (Figs 17, 50, 51, 71 and Perrault 1991)

*Leistus angulicollis* Fairmaire, 1886a: 307, 1986b: 223-224; Tschitscherine, 1903: 22-33; Sciaky, 1994: 209.

*Leistus* (*Neoleistus*), *angulicollis* Perrault, 1991: 16-8.

*Leistus* (s. str.) *angulicollis* Perrault, 1994: 169-170.

**NEW RECORD.** I have examined two specimens, labelled: Yunnan, 27.02N 100.11E, Yulongshan mts., 3600 - 4100 m, 27 v 1993 (male), and Yunnan, 27.02N 100.11E, Yulongshan mts., 4000 m, lgt. Bolm (female).

Compared with the lectotype (Fig. 71) in collection Muséum d'Histoire naturelle, Paris (lectotype designation acc. Perrault 1991: 18-9).

#### *Leistus* (*Evanoleistus*) *farkaši* Sciaky, 1994

*Leistus* (*Evanoleistus*) *farkaši* Sciaky, 1994: 206-207.

**NEW RECORD.** I have examined five specimens, labelled: China, Qinghai, Laji-shan-pass, S. Xining, 3700 - 3900 m, 13-15.vii. 1993, lgt. W. Heinz, 31 specimens, labelled: China, E. Qinghai (Gonghe), 36.32 N 101.04 E, mts. 20 km N



Daotanghe, ca 4200 m, 3 vii 1993, alpine meadow/screel/grassland, lgt M Janata (17 spec.) and K. & B. Březina (14 spec.)

Compared with the paratype in collection J. Farkaš, Praha

***Leistus (Evanoleistus) loebli* Perrault, 1985**

*Leistus (Evanoleistus) loebli* Perrault, 1985a: 16, 1985b: 39

NEW RECORD: I have examined one female specimen, labelled Nepal, prov. Bagmati, Merc Dara, 3200 m, 8 iv 1981 lgt. I. Lohr & A. Smetana

This species was previously known only from the holotype (Perrault 1985a). Compared with holotype in Muséum d'histoire naturelle, Geneva

***Leistus (Evanoleistus) nivium* Andrewes, 1925**

*Leistus nivium* Andrewes, 1925: 312, 1929: 108, Banninger, 1925: 331

*Leistus (Evanoleistus) nivium* Perrault, 1985a: 15, 1985b: 50-51, 1990a: 102-104

NEW RECORD: I have examined 3 specimens, labelled Kachemire, Pahalgam env. 2000 m, vi 1980, lgt. A. Richter, and 3 specimens, labelled India (Kashmir), Pahalgam env. 2200 - 2900 m, 28-31 vii 1980, lgt. W. Hemz

Compared with the holotype in collection Natural History Museum, London

***Leistus (Evanoleistus) nokoensis* Minowa, 1932**

*Leistus nokoensis* Minowa, 1932: 281

*Leistus (Evanoleistus) nokoensis* Perrault, 1985a: 15, 23-24, 1986b: 130

NEW RECORD: I have examined 17 specimens from Taiwan: 16 specimens: Taichung Hsien: Hsuehshan, above Shan-Liu-Gieu Hut, 3200 m, 8 v 1991, 3220 m, 7 v 1991, 3350 m, 10 v 1991; Nantou Hsien: Nienkaoshan, Tancha Hut, 2900 m, 5 v 1991, lgt. A. Smetana, and 1 male: Central Cross Island Highway, 500 - 2700 m, 20 xi - 7 xii 1991, lgt. L. + R. Basmsky

The specimens from Hsuehshan were taken from under bark of fallen firs *Abies kawakamii*. Compared with the type in the collection Taiwan Agricultural Research Institute, Wufeng

**List of *Leistus* species from Yunnan, Sichuan and Gansu**

**Yunnan**

subgenus *Evanoleistus* Jedlicka, 1967

*yunnanus* Banninger, 1925

*kruli* Farkaš, 1993

*kubani* Farkaš, 1993

*brunneus* sp. n.

*deussianus* sp. n.

*nani* sp. n.

*kuarui* sp. n.

*kuarui* sp. n.

subgenus *Leistus* s. str. Froehlig, 1999

*angulicollis* Fumidare, 1886

*businskyi* Švihák, 1994

## Sichuan

subgenus *Evanoletus* Jedlička, 1967  
*crenifer* Tschitscherine, 1903  
*gracilentus* Tschitscherine, 1903  
    = *gracillimus* Tschitscherine, 1903 (syn. by Perrault, 1994)  
*nubicola* Tschitscherine, 1903  
*cylindricus* Sciaky, 1994  
*pavea* Sciaky, 1994  
*perraulti* Sciaky, 1994  
*saevus* Sciaky, 1994  
*sichuanus* Sciaky, 1994  
*drusus* Perrault, 1994  
*barkensis* sp. n.  
*hazeki* sp. n.  
*kaishi* sp. n.  
*kungdingeri* sp. n.  
*longistylus* sp. n.  
*sciakyi* sp. n.  
*shuanmoku* sp. n.  
*usurpatus* sp. n.  
*testatus* Sciaky, in press  
*pseudocrenifer* Sciaky, in press  
*vagus* Sciaky, in press  
subgenus *Leistus* s. str. Froehlig, 1999  
*cycloderus* Tschitscherine, 1903  
*ludmiae* Dvofák, 1994

## Gansu

subgenus *Evanoletus* Jedlička, 1967  
*reflexus* Semenov, 1899  
*behemotum* Sciaky, 1994  
*heime* sp. n.  
*gansuensis* Sciaky, in press

## GENERAL DISCUSSION

Sciaky (1994 and paper in press) mentions the problems concerning the subgeneric assignment of the species of the genus *Leistus* from eastern and southeastern Asia and questions the assignment of some of the Asian species to the subgenus *Neoletus*. I believe that the subgenus *Neoletus* comprises only the three endemic Nearctic species and that the assignment of the species of *Leistus*, known at present from eastern and southeastern Asia to the subgenera *Leistus* s. str. and *Evanoletus* should be reassessed. Also, a redefinition of these subgenera, based on the shape of the aedeagus, seems to be inevitable and may even include erection of new subgenera. However, additional material is still needed, because the number of the species known from the area at present, is by far probably not final. This topic will be addressed in an annotated catalogue of the Holarctic species of the genus *Leistus* which is in preparation as a joint project with Dr R. Sciaky.

## Acknowledgements

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MINI-REVIEW

BANARESCU P. *Zoogeography of Fresh Waters. I. General Distribution and Dispersal of Freshwater Animals*. Wiesbaden: AULA-Verlag, 1990. 5 + 1 pp. Price DM 248.00. ISBN 3-89104-481-X.

The first volume of a very ambitious three volumes compendium dealing with the problem of the distribution and the dispersal of freshwater animals is split into eight chapters. The first one contains introductory information about general biogeography and zoogeography in particular. The introduction is useful for beginners in the field as on only 50 pages covers most of the fundamentals including a survey of individual biogeographical schools.

Second chapter and the most extensive (over 170 pages) covers the problem of the distribution and the dispersal of freshwater fishes. The fish species are categorised into groups: primary, secondary, peripheral and vicarious species, and the groups treated individually. This system of classification is followed in other chapters as well. The third chapter is aimed at higher Crustacea: Decapoda, Peracarida and Syncarida, the fourth is dealing with molluscs, the fifth with some groups of invertebrates like sponges, cnidarians, polychaets and Annelida. Free-living oligochaetes and groups of commensal and parasitic crustaceans. The treatment of the material is changed in the sixth chapter. Instead of dealing with individual higher taxa, the distribution and dispersal of freshwater animals living in temporary pools is summarised, including groups like Anostraca, Conchostraca and Cladocera. Again a selective approach is used in the seventh chapter: only Plecoptera, Trichoptera, Blattoptera and water beetles are dealt with. The eighth chapter is short and summarising some general information about the main biogeographic categories.

The text is documented in 208 distributional maps which helps substantially to the easy orientation in the book material. It seems that the selection of the higher taxa is somewhat biased. Many groups of freshwater animals are missing like rotifers, free-living copepods, cladocerans, ostracods and most of the insects. The authors explains the elimination of such taxa either by their cosmopolitanism on the species level (rotifers) or on the generic one. In the case of freshwater insects, the elimination of some of the orders is based on their ability to fly and thus to avoid the limitation by aquatic habitats. The explanation seems to be a little forced as the problem of the distribution and the dispersal within these groups is as of course studied and some results are available.

Such deficiency is of course important and the student looking for basic information about selected taxa will be disappointed. The use of some of the names of higher taxa like worms, Entomostraca, lower invertebrates (excluding molluscs and arthropods) is of course questionable too.

Regardless this somewhat unbalanced treatment of the material, the book is a solid, mostly descriptive summary of the art of biogeography.

*Vladimír Křížek*

Revision of species of the tribus Mordellistenini from Oriental region. Part 1.  
(Coleoptera: Mordellidae)

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Taxonomy, new species, new combinations, redescrptions, keys, Coleoptera, Mordellidae, Oriental region

**Abstract.** New species *Mordellistena* (s. str.) *nepalensis* sp. n. and *Mordellistena* (s. str.) *altestratoides* sp. n. from Nepal are described. New combinations *Mordellina* (s. str.) *quinquenotata* (Champion), *Glipostenoda daturae* (Blair), *Glipostenoda rufobrunnea* (Champion) and *Mordellistena* Costa and *Glipostenoda defectiva* (Walker) from *Mordella* L. are proposed. *Mordellistena* (s. str.) *tenumanus* Champion and *Mordellistena* (s. str.) *humeronotata* Champion are redescrbed.

INTRODUCTION

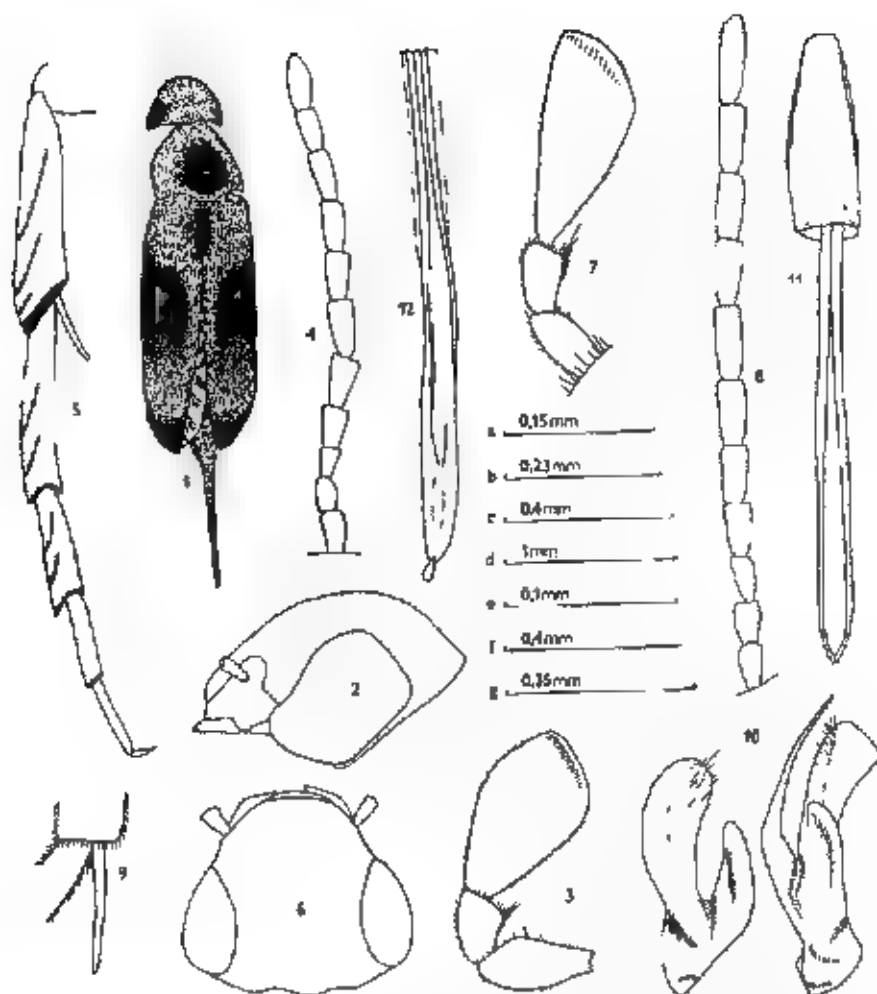
In the present paper the species of the tribus Mordellistenini described from Indian subcontinent are revised. It follows the paper by Franciscolo (1974), the first among recent authors, who paid attention to this topic after the British authors Blair, Champion and Walker. In the paper are not included the species of *Mordellistena humeralis* Linnaeus, 1758 species-group (section II. by Ermisch, 1956), which will be subject of a future paper.

*Mordellina* (s. str.) *quinquenotata* (Champion, 1927) comb. n.

*Mordellistena quinquenotata* Champion, 1927: 53

For its very large, pubescent and very coarsely faceted eyes (Figs 2, 6), this species must be transferred to the genus *Mordellina* Schilsky, 1908 viz. in its the nominotypical subgenus, as suggested by metatibiae armed with only one terminal spur (Fig. 9). Nevertheless, it resembles some species of the *Mordellistena episternalis* Mulsant, 1856 species-group by its extremely prolonged filiform pygidium (Fig. 1) and the build of male external genitalia. Further very characteristic features are: anterior tibiae of male only little curved inwards, but with distinct calf-like swelling, and without longer outstanding hairs, very long filiform antennae (Figs 4, 8); very oblique lateral ridges on metatibiae (Fig. 5). For illustrations of important characters and genitalia of male see Figs 10, 11, 12).

**MATERIAL EXAMINED.** Holotype, female, Kumaon, L. P., Haldwani Divn., 6,923, H. G. C., et alight; deposited in The Natural History Museum, London. 1 male, W. Nepal, Dhawalagiri, Myagdi Distr., Kali-Gandaki-Khola, Tatopani, 1,000-1,400m, 27.28.6.1986. C. Holzschuh leg. deposited in author's collection.



Figs. 1-12. *Mordellistena* (s. str.) *quinquenotata*. Holotypus, female: 1 general view; 2 head (lateral view); 3 maxillary palpus; 4 antenna; 5 posterior tibia and tarsus. Nepal, male: 6 head (dorsal view); 7 maxillary palpus; 8 antenna; 9 terminal spur of metatibia; 10 left and right parameres; 11 phallobasis; 12 penis. Scale: a - 0; b - 6; c - 5; d - 1; e - 3; 7 f - 2; g - 4, 8, 9, 11, 12.

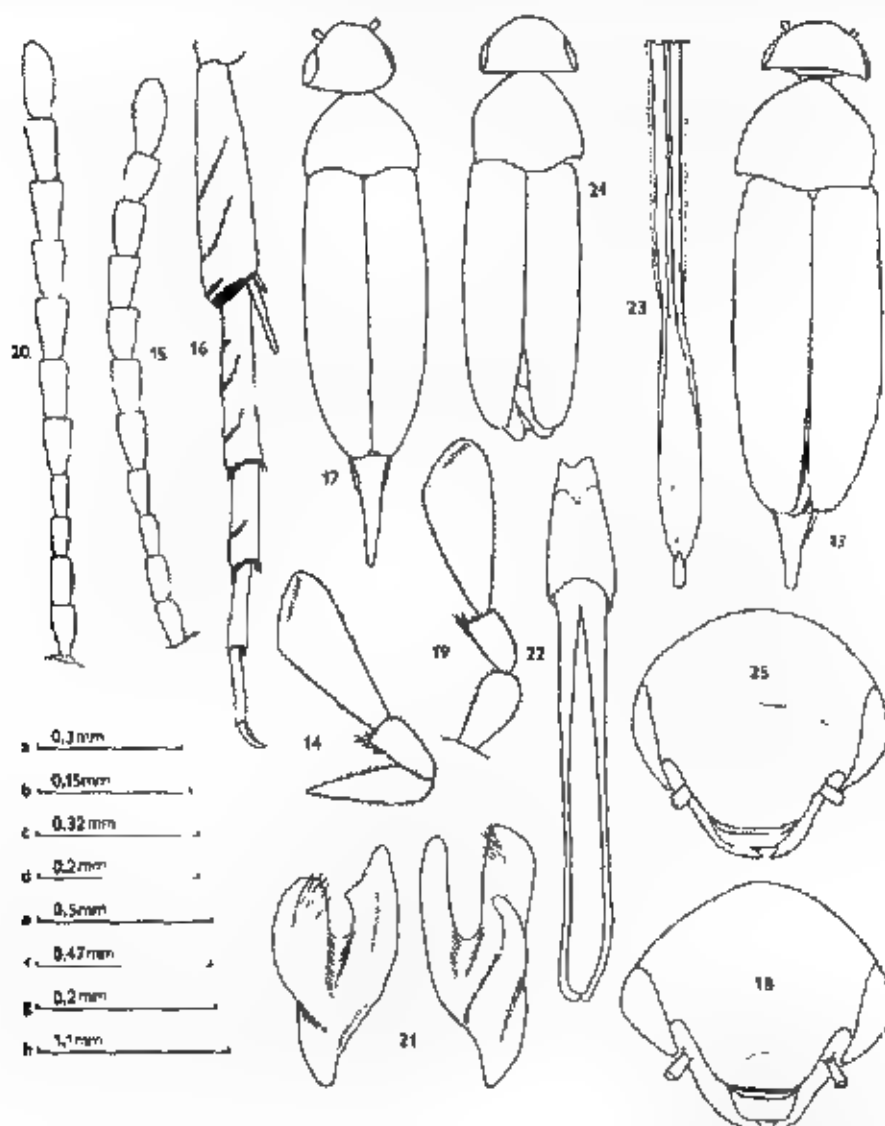
### *Mordellistena* (s. str.) *tenuimanus* Champion, 1927

*Mordellistena tenuimanus* Champion, 1927: 52 - 53

The shape of terminal segment of maxillary palpus (Figs 14, 19) as well as the configuration of ridges on metatibia (Fig. 16) classify this species as a member of *M. parvula* (Gyllenhal, 1827) species-group. Body little convex and rather parallel-sided (Figs 13, 17). Pubescence of dorsal surface uniform, grey-brown with reddish tinge. Anterior portion of the head indistinctly



paler (Fig. 18). Maxillary palpi black-brown, four basal segments of antennae and anterior femora brown, anterior tibiae and tarsi as well as intermediate femora black-brown. Terminal spurs of metatibiae black-brown, outer spur reaching one third of the length of the inner one. Metatibia, besides the apical ridge, with two oblique and equally long lateral ridges reaching two thirds of



Figs 13-25. *Mordellistena* (s. str.) *renkmanus*. Holotypus, female 13. general view; 14. maxillary palpus; 15. antenna; 16. posterior tibia and tarsus. Nepal, male: 17. general view; 18. head (frontal view); 19. maxillary palpus; 20. antenna; 21. left and right paramere; 22. phallosax; 23. penis. *Mordellistena* (s. str.) *ghanii*. Holotypus, male 24. general view; 25. head (frontal view). Scale: a - 15 b - 21, c - 20; d - 14 19; e - 16, f - 8, 25; g - 22, 23, h - 13, 17, 24.

the width of the tibia. The first segment of posterior tarsus with two oblique ridges and a rudiment of the third ridge, the second segment with only one ridge (not with two ridges, as given by Champion, 1927).

**MATERIAL EXAMINED:** Holotypus, female, W. Almora Divn., Sunderbanga V. 8000-12000 feet, June 19. H. G. C. leg. 3087 deposited in collection The Natural History Museum, London. 2 males, Nepal: Kailumandu V. Burhanthaith, 440-1650m, 16.6.1983, M. Brancucci leg. 1 female, W. Nepal, Dhawalagiri, Kuli G. Khola, Gasa-Kalopani, 2000-2500m, 20.6.1986, C. Holzschuh leg. 1 female, Nepal, Lamphokhad, 2000-2500m, 30.9.1979, B. Bhakia leg., all deposited in Naturhistorisches Museum, Basel. (1 male deposited in author's collection).

#### Key to the species of *Mordellistena parvula* species-group from India and Pakistan

- 1/2) Pubescence of body quite black. Outer terminal spur of metatibia distinctly narrower and by two thirds shorter than the inner one. The upper of the two lateral ridges of metatibia longer than the lower one and reaching three fourths of the tibia width (Fig. 29). Nepal *M. nepalensis* sp. n.
- 2/1) Pubescence of elytra pale, golden yellow to red brown.
- 3/4) Frons to a greater extent lighter anteriorly (male, Fig. 18). Pubescence of elytra brightly golden-yellow. Outer terminal spur of metatibia minute, reaching nearly one fifth of the length of the inner one, and very thin. Upper lateral ridge of metatibia running across almost entire width of the tibia. Pakistan *M. glauca* Franciscano, 1974.
- 4/3) Anterior portion of frons only indistinctly lighter than the rest (male, Fig. 25). Pubescence of elytra darker brownish to red-brown. Outer terminal spur of metatibia but slightly thinner and by two thirds shorter than the inner one. The upper lateral ridge of metatibia reaching two thirds of the tibia width. India (Kumaon), Nepal *M. tenuimanus* Champion, 1927.

#### *Mordellistena* (s. str.) *nepalensis* sp. n.

Black, anteclypeus, anterior margin of labrum and tips of galeae yellowish; four basal segments of antennae and anterior femora black-brown. Pubescence brown-black with faint blue-green lustre.

Head flatly convex, prolonged in buccal portion. Width in length ratio as 4.8 : 4.5. Eyes comparatively small, ovate, moderately narrowed towards the insertions of antennae, finely faceted and pubescent. Temples not developed, only a moderately extended tempora border distinct. Second segment of maxillary palpus by one third wider than the third segment, terminal segment elongate securiform, its inner angle strongly rounded and situated within the distal fourth of the segment (Fig. 27). Antennae (Fig. 28) moderately long, segments 2 and 3 equal 3, as wide as and by one fourth shorter than 4., segment 5 1.8 times longer than wide, by one fourth wider and longer than 4., segments becoming gradually shorter distally, segment 10 only 1.5 times longer than wide, terminal segment oblong oval, by one third longer than 10, and twice as long as wide.

Pronotum moderately convex, wider than long (as 6 : 5), its anterior portion moderately prolonged anteriorly. Sides (lateral view) emarginate, posterior angles consequently rectangular.

Scutellum minute, triangular.

Elytra convex, only flatly rounded laterally, 2.4 times longer than their combined width, with rather coarse rasp-like punctures, especially in their basal portion.

Pygidium rather slender, conical, twice as long as hypopygium, without a ringlet of pure hairs at the base.

The fourth segments of both anterior and intermediate tarsi narrow and truncate at the distal end. Metatibia (Fig. 29), besides a short apical ridge, with two very long oblique lateral ridges, the upper one being distinctly longer and running across three fourths of the width of metatibia. The first segment of posterior tarsus with three ridges, the uppermost ridge rudimentary and

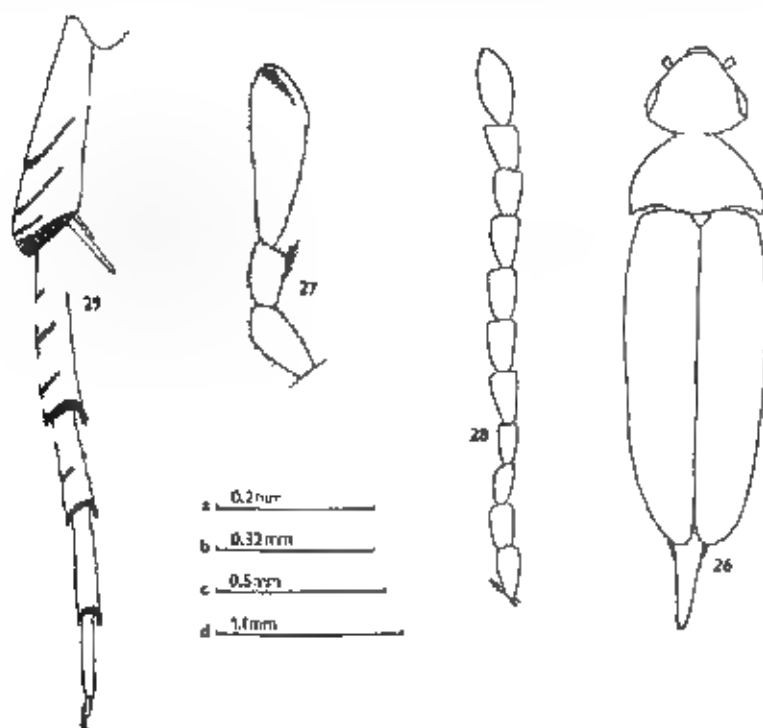
sometimes even missing in smaller specimens (Paratype), second segment with single ridge. Terminal spurs of metatibia black, the outer spur distinctly narrower than the inner one and reaching nearly one third of the latter.

Length from tips of mandibles to tips of elytra 3.3 - 4mm, to apex of pygidium 3.9 - 4.7mm. Male unknown.

TYPE MATERIAL. Holotypus, female: C. Nepal, Kathmandu - Valley, Balaju bc. Kathmandu, 1440m, 3.6.1986, C. Holzschuh leg. Paratypes: 1 female Dhawalagiri, Myagdi Distr., Kain-Gandaki-Khola, Tatopani, 1100-1400m, 27.28.6.1986, C. Holzschuh leg., 1 female Kathmandu Valley, Godavari, 1500m, 15.21.5.1987, C. Holzschuh leg., all deposited in author's collection.

DIFFERENTIAL DIAGNOSIS. The form of maxillary palpus, configuration of ridges on posterior legs and two terminal spurs on metatibia classify this species as a member of *M. parvula* species-group (Ermisch, 1956). Rectangular posterior angles of pronotum and black pubescence suggest its relationship to the European species *M. fusoparvula* Ermisch, 1956.

NAME DERIVATION. Named according to the type locality, situated in Nepal.



Figs 26-29 *Mandelstena (s. str.) nepalensis* sp. n., Holotypus, female. 26. general view, 27. maxillary palpus, 28. antenna, 29. posterior tibia and tarsus. Scale: a - 27, b - 28, c - 29, d - 26.

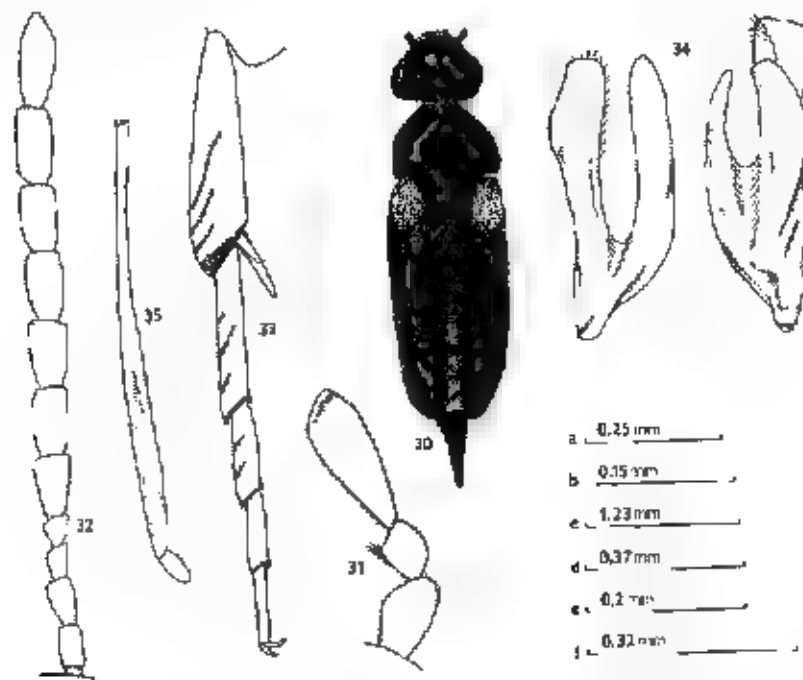
*Mordellistena* (s. str.) *humeronotata* Champion, 1922

*Mordellistena humeronotata* Champion, 1922: 76

Bicoloured, black to black-brown with yellow-brown humeral spot on each elytron. Pubescence bicoloured, too, the black gray pubescence of the body being replaced with golden yellow hairs on the pale humeral spots.

Body rather short and stout, with long antennae and comparatively short pygidium. Each of the antennal segments 5. - 10. twice as long as wide in male, 1.4 - 1.5 times so in female. Maxillary palpi yellow, second segment in male distinctly wider than the third one, terminal segment narrowly securiform, its inner angle situated in the distal fourth of its length (in female somewhat wider and darker). Legs in male brown, posterior ones black-brown, in female anterior legs dark brown, remaining ones black. Both lateral ridges of metatibia oblique, equally long and only slightly reaching over the middle of the width of tibia. The first segment of posterior tarsus with three ridges, the uppermost ridge being often rudimentary or completely missing, second segment with two ridges. Terminal spurs of metatibia yellow brown, the outer spur reaching nearly one third of the length of the inner one. Pygidium twice as long as hypopygium in male, 1.25 - 1.30 times so in female.

Body form, maxillary palpus, antenna, posterior leg and genitalia as figured (Figs 30 - 35).



Figs 30-35. *Mordellistena* (s. str.) *humeronotata*, Lectotypus male: 30, general view; 31, maxillary palpus; 32, antenna; 33, posterior tibia and tarsus; 34, left and right paramere; 35, penis. Scale: a - 31; b - 34; c - 30; d - 33; e - 35, f - 32.

May 4 exsiccato Lectotypes, male India, Kumaon, Raniket, H. G. C. leg. Paratypes 7 ex. the same data; 1 male and 1 female West Bhatkot, Kumaon, 4000 ft. May 20, H. G. C., all deposited in The Natural History Museum, London. Additional very rich material from Nepal and India (W. Bengal) from my collection.

Classification of this species is rather difficult. According to the shape of lateral ridges of metatibia and maxillary palpus, it could best be placed in the *M. parvula* species-group, however two ridges on the second segment of posterior tarsus (only one ridge being developed in species of *M. parvula* species-group) suggest its relationship to the west-palaearctic *M. reichei* Emery 1876, from which it differs especially by the form of maxillary palpus. Thus *M. humeronotata* represents a link between the latter species and *M. parvula* species-group, differing at the same time from all hitherto known species by distinct humeral spots on elytra.

*Mordellutena* (s. str.) *altistriatoides* sp. n.

Black with yellow-brown spots on humera and at the base of elytra. Post- and anteclypeus yellow-brown, labrum, mandibles, four basal segments of antennae, anterior and intermediate legs as well as terminal spurs of metatibiae brown, posterior legs black-brown. Pubescence black-gray with reddish tinge, alternating with golden-yellow pubescence, which covers both basal and humeral spots and, moreover, makes up a narrow sutural band running from the apex of scutellum to the apical fourth of suture as well as a small mediolateral spot at the midlength of each elytron (Fig. 36).

Head rather convex as long as wide, at the mouth parts prolonged anteriorly. Eyes oblong oval, narrowed towards antennal pits. Temples and temporal angles absent. Maxillary palpus in male (Fig. 37) brown with black-brown terminal segment, second segment only a little wider than the third one, terminal segment narrowly securiform with inner angle situated at its distal third; palpus in female completely brown, inner angle situated at the distal fourth of its length. Two basal antennal segments of equal size, segment 3 slightly shorter than and almost as wide as 2, 4 slightly smaller than 3, 5 twice as long as and by one fifth wider than 4, each of the segments 5 - 10: 1.8 times longer than wide, terminal segment somewhat more than twice as long as wide and by one sixth longer than the penultimate segment (Fig. 38), in female of the segments 5 - 10: 1.4 times longer than wide and terminal segment 1.6 times longer than wide.

Pronotum semicircular, with moderate collar-shaped anterior prolongation, maximum width to maximum length ratio as 9 : 7. Anterior angles indistinct, sides (lateral view) only moderately emarginate, posterior angles rectangular and somewhat rounded. Pubescence golden silvery.

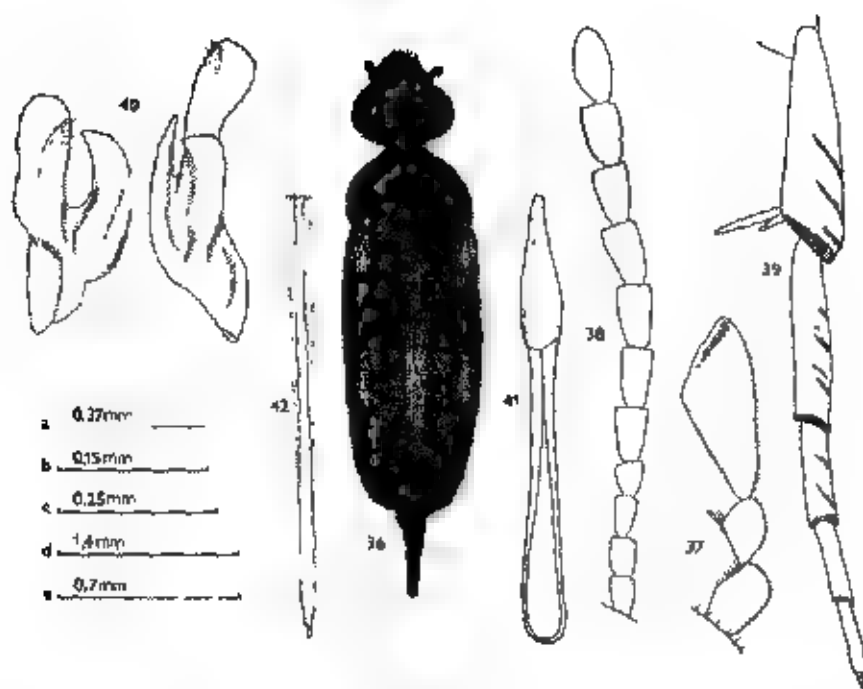
Elytra rather convex 2.1 times longer than their combined width.

Pygidium narrowly conical, three times as long as hypopygium and reaching somewhat more than one half of the length of elytra. Base of pygidium without the fringe of white hairs.

Protibia in male almost straight, not dilated at the base and without longer outstanding hairs. Metatibia (Fig. 39) besides apical ridge with two very oblique lateral ridges, the upper in male somewhat longer than the lower one and slightly exceeding one half of the width of tibia. First segment of posterior tarsus with three ridges, the uppermost ridge mostly rudimentary. Outer terminal spur of metatibia reaching less than one third of the length of the inner one.

Male genitalia as figured (Figs 40, 41, 42).

Length from tips of mandibles to tips of elytra 3.5 - 3.7 mm, to tip of pygidium 4.2 - 4.3 mm.



Figs 36-42. *Mordellistena* (s. str.) *attestriatoides* sp. n. Holotypus, male: 36 general view; 37 maxillary palpus, 38 antenna, 39 posterior tibia and tarsus, 40 left and right paramere, 41 phallobasis, 42 penis. Scale: a - 38, 41, 42, b - 40; c - 37; d - 36, e - 39.

TYPE MATERIAL. Holotypus, male, W Nepal, Dhawalagiri, Mustang distr. Kali-Gandaki Khola, Kalopani, 2500-2800m, 21.6.1986, C. Holzschuh leg. Allotypus, female, W Nepal, Dhawalagiri, Ghar Khola, Chorepan-Sikha, 2000-2800m, 12.6.1986, C. Holzschuh leg. Paratypes: 3 females, the same data as Holotypus, 1 female Nepal, Kathmandu valley, Godavari, 18.5.1989, C. Holzschuh leg., all in author's collection, one paratype (female) in the Natural History Museum, London.

NAME DERIVATION. Derived from *Falsomordellistena attestriata* (Marseul, 1876), related species.

The two Indian species related to *M. reichet* can be distinguished according to the following key:

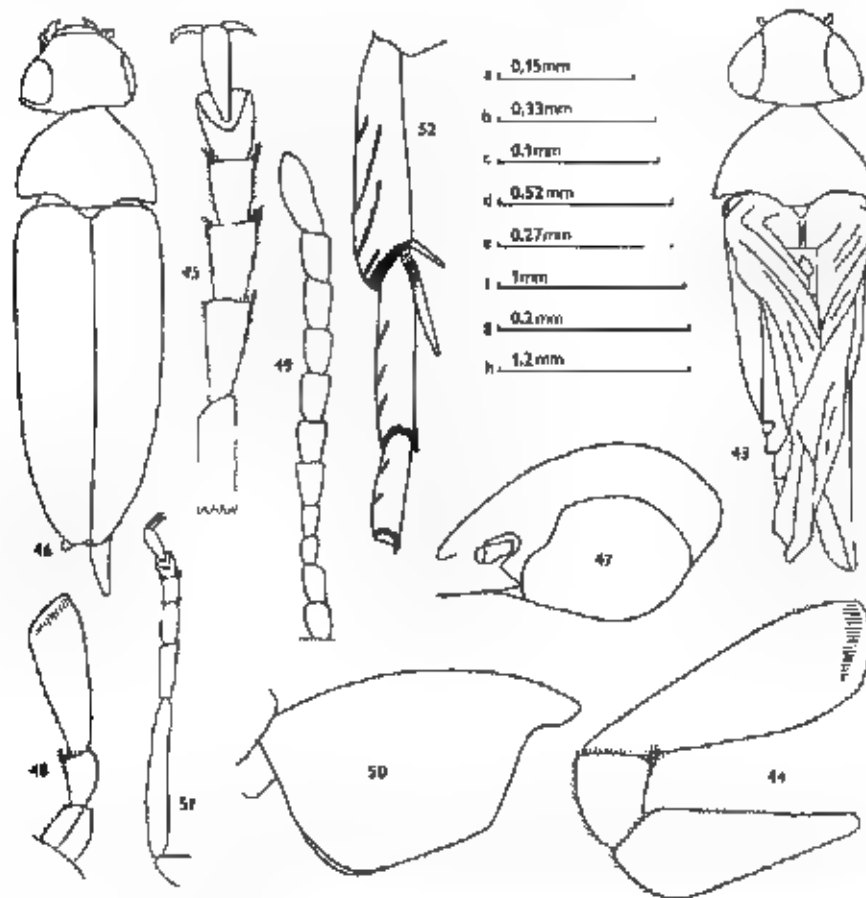
- 1(2) Elytra with red-brown, round and rather extensive humeral spot. Pubescence, apart from golden-yellow hairs on humeral spot, concolorous, grey-red (India, Kumaon, W. Bengal). Nepal. *M. humeronotata*
- 2(1) Elytra with small, red-brown humeral spot narrowly prolonged towards scutellum. Golden-yellow hairs, apart from covering the humeral spot, make up a narrow longitudinal band along suture as well as small medio-lateral spot on each elytron. Nepal. *M. attestriatoides* sp. n.

*Glipostenoda daturae* (Blair, 1922) comb. n.

*Mordellistena daturae* Blair, 1922: 296-297

*Mordellistena* *Pseudomordellistena* *daturae* Franciscolo, 1974: 81-83.

Examination of Lectotype of this species revealed that penultimate segments of both anterior and intermediate tarsi were deeply bilobed (Fig. 45). In view of this, the species can by no means be classified neither in *Mordellistena* Costa, 1854, nor in *Mordellina* Sculsky (as given on the Lectotype label by Franciscolo 1974). Further characters then suggest its accommodation in the genus *Glipostenoda* Emisch, 1950: very large, coarsely faceted and pubescent eyes, form of maxillary palpus (Fig. 44); configuration of ridges and terminal spurs on posterior



Figs 43-52 *Glipostenoda daturae*, Lectotypus, male, 43. general view, 44. maxillary palpus, 45. anterior tarsus *Glipostenoda rufobrunnea*, Holotypus, female, 46. general view, 47. head (lateral view), 48. maxillary palpus, 49. antenna, 50. pronotum (lateral view), 51. anterior tarsus, 52. posterior tibia and tarsus. Scale: a. 43, b. 49, 51, c. 44, d. 52, e. 47, 50, f. 43, g. 45, h. 46.



legs, body form (Fig. 43), colour pattern and also the form of male genitalia. Otherwise is the species characterized by the particular pubescence of middle tarsi and by the shape of parameres (Franciscolo, 1974, Figs. 38-48).

Similarity of two generic names and those of their respective subgenera, namely *Mordellistena* (*Pseudomordellina*) Ermisch, 1952 and *Mordellina* (*Pseudomordellistena*) Ermisch, 1951 resulted in considerable nomenclatorial confusion in the paper by Franciscolo (1974), who repeatedly used the non-existing combination *Mordellistena* (*Pseudomordellistena*). This mistake can probably explain also the contradictions in the paragraph "Affinities" (p. 83), in which he gives "... 14 species of *Mordellistena* (*Pseudomordellistena*) from Africa ..." and later "... all the *Pseudomordellina* so far ...". Moreover, Lectotype is labelled as *Mordellina* (*Pseudomordellistena*) *daturae* and this determination agrees better with some features mentioned in the redescription. Nevertheless, the species must be placed in the genus *Glipostenoda*.

The original description and Franciscolo's (1974) redescription are complemented here with the description of the body form, anterior tarsus and maxillary palpus of male (Figs 43, 44, 45).

**MATERIAL EXAMINED.** Lectotypus, male, Zool. Surv. Ind. + P. H. Gravely - Barkuda Id., Chilka Lake, Ganjam distr., Madras Pres., 3.-4.7.19. Ind. Mus. Coll., B. M. (N. H.); labelled as Lectotype of *Mordellina* (*Pseudomordellistena*) *daturae* (Blair), by Franciscolo; deposited in The Natural History Museum, London. It is considerably damaged, lacking both elytra, parts of legs, pygidium, etc.

### *Glipostenoda rufobrunnea* (Champion, 1927) comb. n.

*Mordellistena rufobrunnea* Champion, 1927: 52.

Because of deeply notched fourth segments of anterior and intermediate tarsi (Fig. 51), pubescent and coarsely faceted eyes and narrow terminal segment of maxillary palpus belongs this species also to the genus *Glipostenoda*. It is completely red-brown and covered with golden-yellow pubescence. The fourth antennal segment slightly larger than the third one, each of the segments fifth to tenth 1.4 times longer than wide, terminal segment asymmetrical, with incurved outer margin (Fig. 49). Terminal segment of maxillary palpus (Fig. 48) narrow at inner angle situated in the distal fourth of segment and strongly rounded. Posterior angles of pronotum broadly obtusely rounded. Elytra 2.3 times longer than their combined width. Metatibia (Fig. 52), besides the apical ridge, with three very oblique and long lateral ridges, the uppermost of them rudimentary. The first segment of posterior tarsus with four oblique ridges (the uppermost one rudimentary), second segment with two ridges, the third one without ridges. Outer terminal spur of metatibia reaching nearly one third of the length of the inner one.

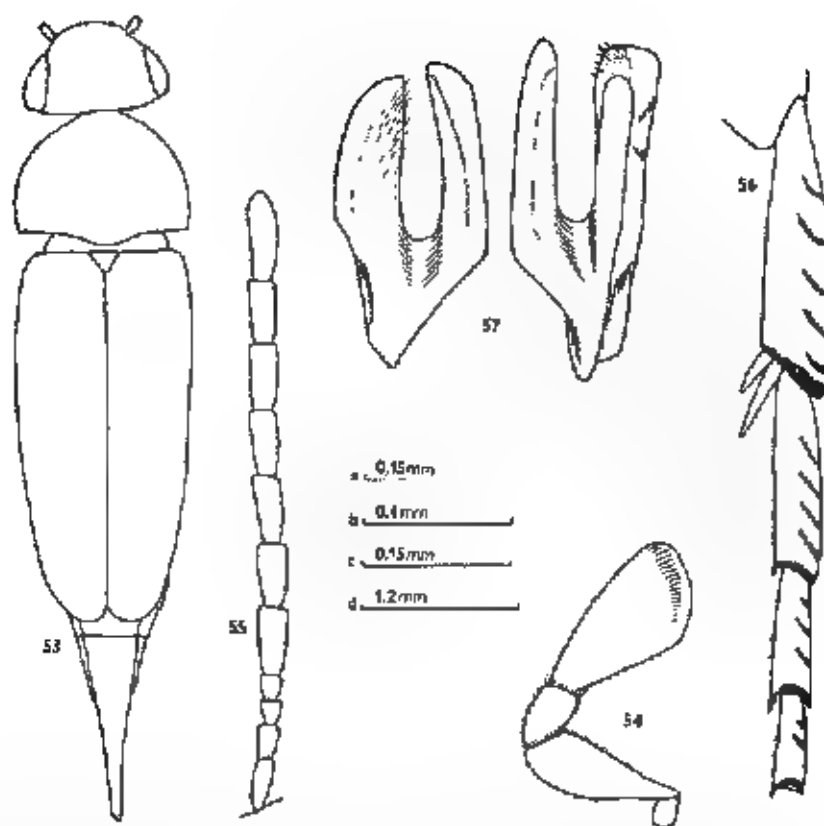
Length (including pygidium) 4.5mm.

**MATERIAL EXAMINED.** Holotypus, female, India, Kannan, Halwani Dist., H. C. Champion leg., deposited in The Natural History Museum, London.

### *Glipostenoda defectiva* (Walker, 1859) comb. n.

*Mordella defectiva* Walker, 1859: 260.

**ORIGINAL DESCRIPTION.** Nigra, longi-subfusiformis, femoribus tibusque ferrugineis, abdomine foem. attenuato elytra superante. Long. 2 lin.



Figs 53-57. *Glipostenoda defectiva*, Holotypus, male. 53 - general view; 54 - maxillary palpus; 55 - antenna; 56 - posterior tibia and tarsus; 57 - left and right paramere. Scale: a - 54; b - 55, 56; c - 57; d - 53.

**REDESCRIPTION.** Body rather narrow and parallel-sided (Fig. 53). Basic colouration black-brown, only head and appendages red-brown. Pubescence uniform, golden-brown.

Head rather convex, wider than long (as 6.3 : 4.2), buccal area regularly rounded, not prominent. Eyes large and broad, rather coarsely faceted, with short and sparse hairs. Temples very narrow, with narrow and elongate temporal angle. Terminal segment of maxillary palpus black-brown with paler base, elongate securiform (Fig. 54), the strongly rounded inner angle situated at two thirds of its length; second segment by nearly one half wider than the third one. Antennae (Fig. 55) long, brown, segment 1 by one third longer than 2, 3 minute, by one third shorter and by one fifth narrower than 2; 3 and 4 subequal, 5 approximately three times as long as, and by one fifth wider than 4; segments 5 - 10 cylindrical, each of them nearly 2.5 times longer than wide; terminal segment three times as long as wide as wide as, and by one fourth longer than the preceding one.

Pronotum rather flatly convex, wider than long (as 7.7 : 6.2). Anterior margin of pronotum only with slight collar-shaped projection; anterior angles (dorsal view) hardly distinct. Sided (lateral view) straight, posterior angles obtuse, gently rounded at the apex.

Elytra rather parallel sided in basal third, gradually narrowed behind it, 2.2 times longer than their combined width

Pygidium narrowly conical, twice as long as hypopygium

Anterior tibia gently curved inwards, without calf-like swelling and without longer outstanding hairs at the base. The first segment of anterior tarsus by one third longer than the second one, that by one third longer than the third one, fourth segment quadrante, deeply bilobed. Intermediate tarsus shorter than mesotibia. Metatibia (Fig. 56), besides apical ridge, with four short lateral ridges, which are parallel to the posterior edge of tibia and, in fact, as long as the apical ridge. The first segment of posterior tarsus with four, second one with three and the third segment with two very short ridges. Terminal spurs of metatibia red-brown, inner spur twice as long as the outer one.

Male genitalia as figured (Fig. 57)

Length from tips of mandibles to tips of elytra 4.7 mm, to tip of pygidium 6.0 mm

**MATERIAL EXAMINED** Holotype, male 63.52 (locality in original description given as "Ceylon" = A. M. - N. H. N. 16 1859 p. 258) bearing manuscript label (not red) "*Mordella defectiva* n. sp." and the red designation "Type H T", complemented with a later identification label "*Mordellistena defectiva*", deposited in collection The Natural History Museum, London.

#### Key to known species of *Ghpostenoda* from India

1. 4) Lateral ridges on metatibia long and oblique, not parallel to the apical edge of tibia
2. 1) Dorsal surface of segments of intermediate tarsi covered with long and dense hairs. Metatibia with two lateral ridges. Outer terminal spur of metatibia reaching one fourth of the length of the inner one. Terminal segment of antenna only slightly longer than the penultimate one. India (Orissa). *G. daturae*
3. 2) Hairs on dorsal surface of segments of intermediate tarsi short and sparse, as usual. Metatibia with three lateral ridges (uppermost rudimentary). Outer terminal spur reaching one third of the inner one. Terminal segment of antenna almost twice as long as the preceding one. India (Uttarpradesh). *G. rufibrunnea*
4. 1) Lateral ridges of metatibia short and parallel to the apical edge of tibia. Body blackened, black-brown with red-brown head. Metatibia, besides the apical ridge, with four lateral ridges. First segment of posterior tarsus with four ridges, second and third segment with three and two ridges respectively. Sri Lanka. *G. defectiva*

#### A c k n o w l e d g e m e n t s

It is my pleasant duty to express my thanks to I. Jessop, M. D. Kerley and D. Kempster (all the Natural History Museum, London), who enabled me to study the material in their charge.

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**Assessment of *Amblyseius barkeri* (Acarina: Phytoseiidae) as a control agent for thrips on greenhouse cucumbers**

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**Biological control, cucumber growth, thrips population dynamics, predator release timing, aggregative response, *Amblyseius barkeri* (= *A. mckenziei*), *Thrips tabaci*, *Frankliniella occidentalis***

**Abstract.** Control of onion thrips, *Thrips tabaci*, and western flower thrips, *Frankliniella occidentalis*, by the predatory mite *Amblyseius barkeri* (= *Amblyseius mckenziei*) was investigated on marked cucumber plants in the early and late phase of cultivation under production greenhouse conditions. Most trials did not demonstrate efficient biological control of thrips. For both thrips species, no differences between thrips population densities on treated and control plants were observed when the total introduction of predators was less than or equal to 200 individuals per plant. However, we ascertained a slower thrips population increase during the early vegetative growth phase of cucumber than at the later phase of fruit production. As a result of this, release of predators later in the production cycle failed to control thrips sufficient to prevent economic injury. Consequently the predator appeared unreliable in spite of a rapid increase in density after introduction of a total of 1 000 predators per plant. The only satisfactory result was obtained with an early application of predators (total of 3 500 predators/plant) where both thrips species were present. An extremely low predatory ability to aggregate in areas of high prey density appeared both on the leaf and the plant scale. We conclude that weak aggregative response of the predator and changes in the rate of plant and thrips development during cultivation are crucial factors related to biocontrol unreliability even with high *A. barkeri* application rates.

#### INTRODUCTION

In spite of the efficient biological control of two key cucumber pests (two-spotted spider mite, *Tetranychus urticae* Koch, and glasshouse whitefly *Trialeurodes vaporariorum* Westwood) under greenhouse conditions pest management programs in many production areas in central Europe must now be expanded to include formerly less important pests: onion thrips, *Thrips tabaci* Linderman, and, recently, western flower thrips, *Frankliniella occidentalis* Pergande (Schliephake 1988, Jensen & Tunvad 1989, Peiskun 1989, Jarošský 1991). Thrips are difficult pests to manage. Few effective and registered pesticides are available for control, and most pesticides are not compatible with biological control agents.

Two species of phytoseiid predators, *Amblyseius barkeri* Hughes (= *Amblyseius mckenziei* Schuster et Pritchard) and *Amblyseius cucumeris* Oudemans, are used as control agents. *Amblyseius barkeri* is the first commercially produced predatory mite (Ramakers & Lieburg 1982). In former Czechoslovakia, the predatory mite mass production and preliminary control experiments started in 1986 (Mouas 1987, Táborský et al. 1988). Further results appeared controversial (Pliva & Jarošský 1991), as did reports from other countries (Stenseth 1986, Ravensberg & Asten 1987, Popov et al. 1987, Hansen & Geydt 1987, Hansen 1988, 1989). The results showed a clear need for a better theoretical and experimental basis of experiments including more reliable sampling procedures (Steiner 1990), evaluation of the influence of climatic,

increase rates and distributions of thrips populations (Hanson 1989), consideration of the interactions of thrips population dynamics with growing cucumber plants (Weiler et al 1990), and the examination of components of the predation process (Barker & Sahel's 1989, Shipp & Whitfield 1991).

This paper is aimed at evaluating further aspects of predatory applications based on field investigation of the predator on marked plants. We examine biocontrol efficiency of predatory mite introductions at different phases of cucumber cultivation, and implications of the lack of predator aggregation in areas of high prey density.

## MATERIAL AND METHODS

Experiments were conducted over a four year period in greenhouse cucumber crops under biological control of two species of mite predators in central Bohemia (Czech Republic) (Table 1). The experimental plots were established in commercial greenhouses where biological control had been practised for several years, and where thrips do not constitute pest management problem.

During the whole period of cucumber cultivation thrips species composition in the trial stands was monitored by taking weekly random samples of about fifty adult from leaves. To avoid edge effects end plants and rows were not sampled, except in experiment F where an effect of migration from surrounding crops was examined. On both leaf sides in trials of marked plants mature stages of predatory mites and thrips were removed with the help of a fine hand lens. Data were recorded either for individual leaves (experimental type A in Table 1) or for whole plants (experimental type C).

*Amblyseius Anderti* was produced using standard commercial rearing procedures (Kammar's & Lickburg 1982). Before releases, numbers of predators were checked under stereo-microscope in repeated samples of whole leaves of cucumber cucurbit containing the predators and no food.

The predators were distributed in trays on the leaves of every third plant in experiments A-E, and on each plant in experiment F. The total number of predators introduced per plant in individual experiments and the time of introduction are given in Table 2. In experiments B and F, and the first introduction in A, predator releases were made in the early cultivation period, corresponding to a plant with rapid vegetative growth before fruit production. (The reasons to require earlier releases in A, B and F were made in the late growth period when plants had shifted to fruit production and reduced vegetative growth (Weiler et al 1990). In experiments A and C of predators before thrips infestation occurred the principle of pre-establishment (Kammar's 1983, Hanson 1989) was applied by making the just two releases eight predators per plant in A and the first release of 10 predators per plant in experiment C. Later, thrips were apparent. The first release in experiments A and C, and all releases in B, D and F were made after observing the first symptoms of thrips damage on leaves. In experiment F application was carried out when the thrips population density reached about three thrips per leaf. In experiments B and D, thrips densities were about one/leaf. The densities were determined during weekly random samples aimed at monitoring of thrips species composition.

For experiments A-D with total predatory mite introductions of 200 predators per plant (Table 2) growth of thrips populations was compared with that in control plots without predators by assessing population densities on marked plants (Table 1). Population increases over time were evaluated by expressing all logarithms of the mean thrips counts per square centimetre as completed data in tables with regressions, tests for equality of slopes of several regression lines and unplanned comparisons (T-test). In all experimental sets of regression lines were used for further analyses of differences among thrips densities on treated and control plants. Simple regressions of predators on prey densities per leaf and plant in E and F experimental times, respectively, were carried out for assessment of predator aggregation response.

Analyses were made weekly at least once either with establishment of predators control, or small, large and high density trials. All statistical calculations were made according to Sokal & Rohlf (1991).

## RESULTS

### Efficiency of control

*Frankliniella occidentalis* infested some crops after 1989 (Table 2). At the beginning of the season both thrips species usually occurred together, but except in experiment F either *Thrips tabaci* or *F. occidentalis* predominated after the trials started.

Where total introductions of predatory mite were less than or equal to 200 individuals per plant (experiments A-D in Table 2) no significant differences in rate of thrips increase were

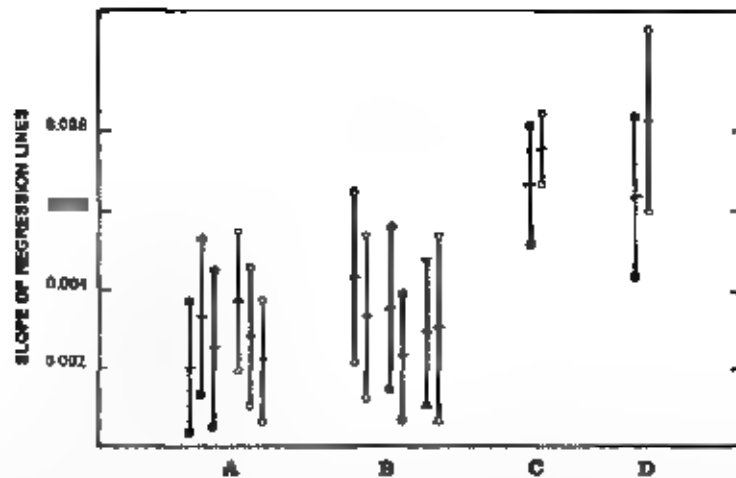


Fig. 1 Comparison of rates of thrips population increases using slopes of regression lines of thrips numbers (log mean+1, on time in A-D experiments). Mean rates whose 95% confidence intervals overlap do not differ significantly. Comparison of marked (dots and closed triangles) and control (circles and open triangles) plots for types with leaf (dots and circles) and plant (triangles) counting.

found between treated and control plots for either thrips species. The control remained unsuccessful even with application of 1,000 predatory mites per plant (experiment E). The only satisfactory biocontrol was reached at the highest total introduction rate of 3,500 predators per plant (experiment F).

Fig. 1 depicts the slope of the regression of the mean rates of thrips population increases on treated and control plants (experiments A-D) over time. In all cases, the log of thrips densities over calendar time increased linearly, though with concomitant significant deviations from linearity. We observed an increase in the rate of population growth between early season (A and B) and late season (C and D) experiments. Average common regression slopes of population increments on marked plants changed from 0.0021 and 0.0026 for A and B to 0.0065 and 0.0066

Table 1. Description of experimental plots and experimental types. Cucumber plants were grown in soil, under normal commercial growing conditions (range of temperatures 18-31 °C, > 85% mean relative humidity).

Experiment	plot (m <sup>2</sup> ) area	cult. var.	growth period	experimental type	experimental period
A	2 400	Bella	March-July, 87	L, 3 exp. & 3 control plants	7.5-4.6.
B	500	Sandra	April-July, 89	L, 2 exp. & 2 control plants P, 50, 50, 25 exp. & 50, 50, 25 control plants	24.4-1.6. 26.4-26.5
C	1 000	Sandra	April-July, 89	L, 1 exp. & 1 control plant	13.6-3.7
D	5 000	Bella	March-July, 87	L, 1 exp. & 1 control plant	14.7-28.7
E	5 000	Bella	February-July, 91	L, 2 experiment plants	30.4-12.7
F	190 / 240	Sandra	May-August, 90	L, 4 experiment plants	25.5-7.7

L: data recorded for individual leaves of marked plants

P: data recorded for whole marked plants

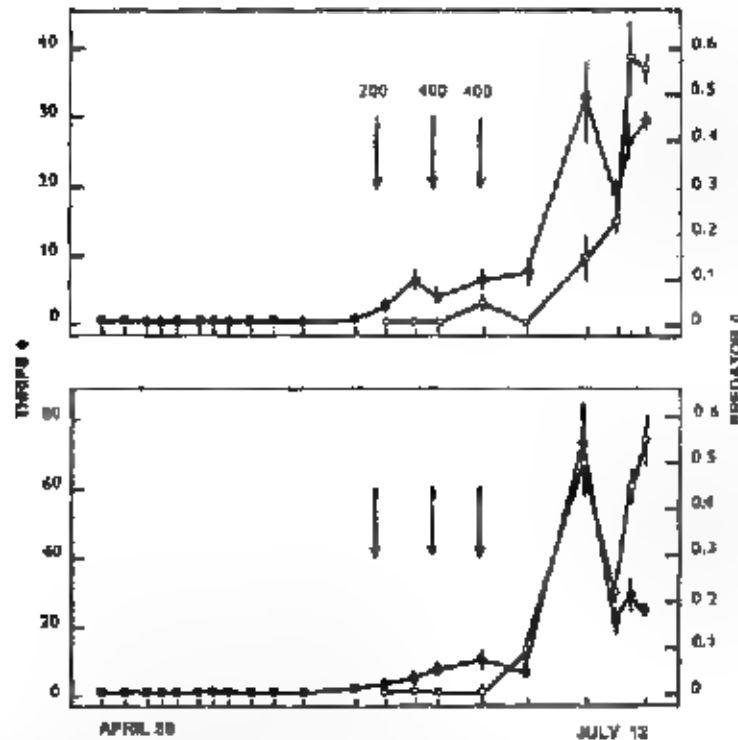


Fig. 2. Population dynamics of thrips (dots) and predatory mites (circles) on two marked plants in experiment E. Means  $\pm$  standard errors. Arrows indicate applications of predatory mite.

for C and D respectively. No differences between treated and control plants were obtained either by counting thrips on single leaves (L-type experiment) or whole plants (P-type experiment), or for different timing of predator release, pre-establishment (experiment A and C), and low thrips density introductions (B and D).

The failure of different timing of introductions according to pest density corroborates the result of experiment E (Fig. 2). Three batches of 200, 400 and 400 predatory mites per plant were applied at the phase of fruit production in 6, 13 and 20 June (Table 1). The thrips population was well established by this time but had not reached suggested economic injury level of about 10 individuals per leaf (Hansen 1988, Steiner 1990). A very similar predator-prey pattern on both marked plants, with both predator and prey increase, was observed. We recorded the highest predatory mite densities in our experiments during the late phase of cultivation however the pest density was already too high to prevent plant damage.

In experiment F, two small neighbouring trial plots were surrounded by larger stands with different crops that were also infested by thrips. As a result of immigration into the experimental plots, a mixed infestation about 1:1 by *E. occidentalis* and *T. tabaci* occurred (Table 2). Fourteen days after the last predatory release in the two mid stand plants the thrips were presumed exterminated because no pests and predators were found afterwards (Fig. 3). On both

edge marked plants low population densities of both predators and thrips persisted until the end of the experiment.

#### Aggregative response of predators

Ten days after the last random spreading of bran with predatory mites the regression relationships between the mean numbers of predators plotted against mean numbers of prey did not significantly differ neither among single leaves nor among whole plants. These relationships between numbers of predators and prey were considered a reliable estimate of aggregative response.

On whole plants, high prey density was usually related to relatively high predator density. On the other hand, there were often individual leaves with relatively high abundance of predatory mites and low abundance of thrips, and leaves where there was high abundance of thrips but no predators (Fig. 4). Consequently, the relationship between the number of thrips and predatory mites was much more significant per plant ( $p < 0.001$ ) than per leaf ( $0.05 < p < 0.1$ ). The former explained 26% of predator variability of occurrence while the latter 4% only. However, the slope of aggregation relationship did not differ significantly between the leaf and plant scale. The aggregative response was extremely weak but significant, with a common slope for both scales 0.0009.

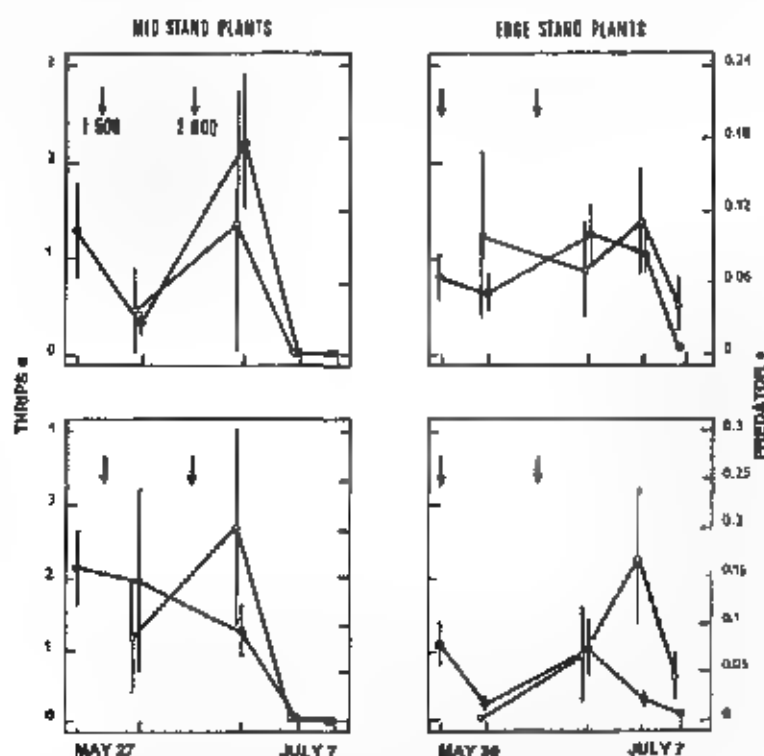


Fig. 3. Population dynamics of thrips (dots) and predatory mites (circles) on four marked plants in experiment F. Means  $\pm$  standard errors. Arrows indicate applications of predatory mite.



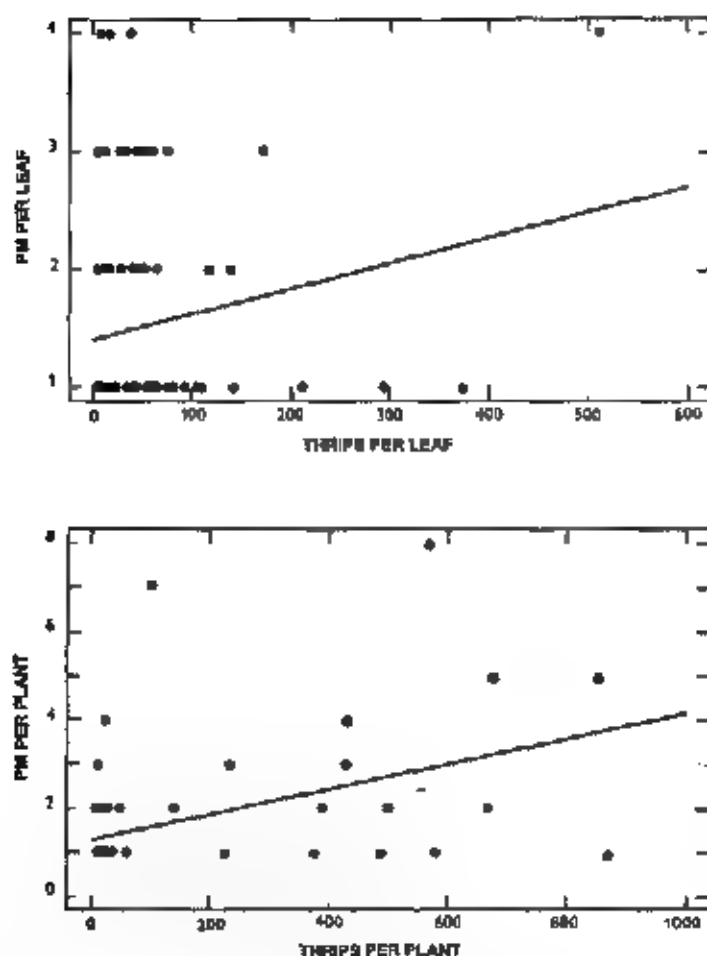


Fig. 4 Relationship between the number of predatory mites (PM) and its thrips prey per cucumber leaf (above) and plant (below). Data based on experiment E for leaf and experiment B for plant scale

## DISCUSSION

### Sampling procedure

The recorded predatory mite densities seem low in comparison with studies in which numbers of predators were determined in more precise way on detached leaves under the stereomicroscope, and where predatory eggs were also sometimes included (Ramakers 1980, 1983, Táborský et al. 1988). On the other hand, the data are comparable with other results where similarly mobile stages of the mites were counted in the field (Hansen 1988, 1989). Systematic errors probably originated in this way because this method is likely to underestimate actual predatory mite numbers. However, it should not influence the evaluation of predatory mite behaviour and predator impact on thrips population dynamics.

Table 2. Survey of introduction of *Amblyseius barkeri* against *Thrips tabaci* and *Frankliniella occidentalis* at individual (A-F) experiments

Experiment	predators per plant (total)	time of introductions	<i>Thrips</i> species
A	24	23 April, 13, 27 May	T
B	50	21 April	F
C	200	3, 20 June	F
D	200	14 July	T
E	1 000	6, 13, 20 July	T
F	3 500	30 May, 14 July	T+F

T *Thrips tabaci*

F *Frankliniella occidentalis*

### Predator introductions and plant growth

No differences in population growth of pests on treated and control plants were found either for experiment B where 50 predators/plant were introduced or experiment C and D with introductions of 200 predatory mites/plant. However, the introductions in B were made in an early season plant growth with on average 18 leaves at the time of introduction. The introductions in experiments C and D were made in late season on plants with about 140 leaves. Thus a similar number of predatory mites/leaf was released in all experiments (approximately 0.4 predatory mite in B and 0.7 in C and D). In addition, in experiment B the early growth phase thrips populations per leaf were very low at a time of rapid growth of cucumber plants. In experiments C and D, thrips densities were in an accelerated phase of exponential growth, coinciding with a time of slow growth of mature plants. The differences in thrips population growth rate are clearly demonstrated in Fig. 1.

Therefore, a direct comparison of experiment B with C and D by release rates of control agents is of limited value. For such a comparison, records enabling the evaluation of interactions of thrips population dynamics and growing cucumber plants must be taken. Recommended release rates of predator mites/plant or m<sup>2</sup> should take into consideration the size and the developmental phase of the plants, as well as the initial thrips population density.

### Experiments

Experiments A-D. The higher rate of population increase of thrips was probably also related to higher day temperature accumulation in late experiments. To prevent the effect of higher temperature accumulation in warm late season it would be necessary to replace calendar time by the sums of effective temperatures above thrips developmental thresholds. However, the data on lower developmental thresholds of *F. occidentalis* and *T. tabaci* are controversial (Harris et al. 1936, Lewis 1973, Lublinkhof & Foster 1977, Edelson & Magaro 1988), and real values for greenhouse cucumbers are probably not known so far. The evaluation of treated and control plants in early and late season was carried out under the same climatic conditions and thus the change in rate of population increase between early and late experiments did not influence our comparisons of treated and control plants. However, the sums should increase preciseness of the results by elimination of thrips growth rate deviations from linearity. Because the population growth of both species may be expected to be exponential (cf. Kawai 1990) the growth

should change into linear without significant deviations from linearity by plotting log thrips density against time.

Experiment 1: The successful inundative regulation of a mixed population of *F. occidentalis* and *T. tabaci* proved a biocontrol potential of predatory mite for both species. The presence of predators and thrips till the end of the observation period on y on edge plants suggested an immigration of thrips from surrounding areas, and a possible role of predators on the stand edges as a buffer against thrips infestation. A similar role was considered for the predatory mite *Phytoseiulus persimilis* Athias-Henrot (1990) after inundative releasing against *Tetranychus urticae* (Osborne et al. 1985; Jarošík & Pliva 1990).

#### Aggregation behaviour

Both *A. barkeri* and the other commercially produced thrips phytoseiid predator *A. cucumeris* are polyphagous. The distributions of *F. occidentalis* and *A. cucumeris* were found to be clumped (Sterner 1990). However, the aggregation was weak in comparison with the patchiness of the more specialized phytoseiid predator *P. persimilis* and its prey *T. urticae* (Bachman 1981). Jarošík (1990) ascertained for *P. persimilis* per cucumber leaf about 167x stronger aggregative response than was the value for *A. barkeri* in the present study. These findings correspond with the theory of a direct increase in degree of predator aggregation as polyphagy decreases (Hassell 1976).

In a highly aggregated population of a phytoseiid predator and its prey, dispersion and attraction between host plant, herbivore and predator are often directed by a system of semiochemicals (Dicke 1986). The predators may be adapted to search for prey which aggregate (Eveleigh & Chang 1982). In such cases, several searching levels corresponding to different scales may be specified (Sabelis & Dicke 1985), and the predators may differ in aggregation at the scales searched. The same slope of aggregative response of *A. barkeri* on leaf and plant scale may indicate that behavioral searching patterns did not differ for different searching levels, and that searching without chemical cues is more probable for this omnivorous species. Similar to congeneric *A. degenerans* (Herlese) (Eveleigh & Chang 1982), *A. barkeri* may not be adapted to search for prey which aggregate.

Because phytoseiid mites are not capable of killing large number of prey, in order to effectively suppress the explosive growth of pests they must show a high numerical response leading to aggregation if released inoculatively. The aggregative response, however, may not be as crucial if it is feasible to rear and release them in large numbers (Sabelis 1985). Nevertheless, in the system under study, the ability of predators to aggregate in areas of high prey density may remain crucial, in spite of a mass rearing and release strategy. Gillespie (1989) found stronger correlation between predators and thrips for *A. cucumeris*, and the closer predator-prey relationship may coincide with more effective control of thrips on cucumbers exerted by this species (Elliott et al. 1987; Lindhagen & Nedstam 1988; Gillespie 1989).

#### Implications for control

Because of its lack of aggregation, a control strategy using *A. barkeri* to control *F. occidentalis* or *T. tabaci* may be efficient only using mass inundation. Hansen (1989) hypothesizes that the system is independent of introductory rates above a minimum of about 300-400 predators/m<sup>2</sup>, and the explanation of differences in biocontrol outcomes relates to different rates of thrips growth. We actually have demonstrated differences in thrips population growth rate during a season. It suggests that biocontrol using this mite may be unreliable even with high release rates when thrips population growth rates are high.



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**Review of Scorpionida from Thailand with descriptions of  
*Thaicharmus mahunkai* gen. et sp. n. and *Lychas krati* sp. n. (Buthidae)**

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**Taxonomy, distribution, descriptions, new genus, new species, Scorpionida, Buthidae, *Thaicharmus* gen. n., *Lychas*, Thailand, Oriental region**

**Abstract.** A list of and a key for all species known and believed to occur in Thailand are given. *Thaicharmus* gen. n. with the type species *T. mahunkai* sp. n. is described. The new genus is related to the Indian genus *Charmus*, from which it differs by the presence of a subocular tubercle, and to the African genus *Butholoides*, from which it differs in having 2 (including apical row) cutting edges on the movable fingers of pedipalps. *Lychas krati* sp. n. is described and a checklist for all species of the genus *Lychas* is provided. *Lychas mucronatus* is for the first time recorded from South and North Vietnam and *Locheles australasiae* for the first time from North Vietnam.

**TAXONOMIC PART**

***Isometrus (Isometrus) maculatus* (De Geer, 1778)**

- ? *Scorpio europaeus* Linnaeus, 1758: 625; Fabricius, 1793: 435  
*Isometrus europaeus* Linnberg, 1898: 86; Pocock, 1899: 835; Pocock, 1900: 46; Pocock, 1902: 38  
*Isometrus* [= *Raddyanus* (sic)] *europaeus* Tikader & Bastawade, 1983: 286  
*Scorpio americanus* Linnaeus, 1758: 624; Fabricius, 1775: 399 (syn. by De Geer, 1778: 346; Kraepelin, 1891: 245)  
*Scorpio americanus* Fabricius, 1793: 434; Herbst, 1800: 60 (syn. by Kraepelin, 1891: 245)  
*Lychas americanus* C. L. Koch, 1845: 2; Cambridge, 1869: 543  
*Centruroides (Isometrus) americanus* Peters, 1862: 515  
*Scorpio maculatus* De Geer, 1778: 346; Gervais, 1844: 57  
*Lychas maculatus* C. L. Koch, 1845: 2; Cambridge, 1869: 543  
*Isometrus maculatus* Thorell, 1876: 8; Pavesi, 1881: 537; L. Koch, 1885: 6; Thorell, 1888: 405; Oates, 1888: 250; Kraepelin, 1891: 245; Linnberg, 1897: 83; Kraepelin, 1899: 66; Simon, 1899: 120; Werner, 1902: 599; Kraepelin, 1916: 34; Giauvert, 1925: 117; Roewer, 1943: 217; Mello-Lopes, 1945: 241; Giauvert, 1963: 183; Probst, 1972: 11; Probst, 1973: 325; L. E. Koch, 1977: 152; Kováčik, 1992: 183  
*Isometrus (Isometrus) maculatus* Vachon, 1972: 177; Vachon, 1976: 38; Kováčik, 1994: 202  
*Scorpio dentatus* Herbst, 1800: 55 (syn. by C. L. Koch, 1845: 1)  
*Buthus (Isometrus) fitum* Hemprich & Ehrenberg, 1828: pl. fig. 3; Hemprich & Ehrenberg, 1829: 352 (syn. Pavesi, 1881: 537)  
*Astron fitum* Gervais, 1844: 52  
*Lychas paraensis* C. L. Koch, 1845: 6 (syn. by Kraepelin, 1891: 245)  
*Scorpio (Lychas) gabonensis* Lucas, 1858: 430 (syn. Pavesi, 1881: 537)  
*Scorpio (Lychas) guineensis* Lucas, 1858: 432 (syn. Pavesi, 1881: 537)  
? *Isometrus sardicus* Karsch, 1879: 116 (syn. by Kraepelin, 1891: 245)

**Comments.** This is a cosmopolitan species more widespread than any other scorpion. It occurs in South America, the Antilles, USA (Florida), Costa Rica, Africa, Madagascar, Pakistan, India, Sri Lanka, China, Myanmar, Thailand, Laos, Cambodia, Vietnam, Malaysia, Indonesia, New Guinea, and Australia (e. g. Vachon 1972: 178).

I have not seen any specimens from Thailand but Vachon (1972: 178, fig. 21) recorded this species from the Thailand - Myanmar and Thailand - Malaysia border regions

*Isometrus (Reddyanus) vittatus* Pocock, 1900

*Isometrus vittatus* Pocock, 1900: 50

*Isometrus* (*Reddyanus*) *vittatus* Vachon, 1972: 177; Vachon, 1976: 39; Kovarik, 1994: 202

*Isometrus* (*Reddyanus*) [*sic*] *vittatus* Tikader & Bastawade, 1983: 257

Comments. This species has been recorded from India (Pocock 1900, Tikader & Bastawade 1983, Vachon 1972), Cambodia, and Laos (Page 1933, 1936, Vachon 1972), and it is therefore assumed to occur in Myanmar and Thailand as well.

*Lychas* C. L. Koch, 1845

*Phanoma* C. L. Koch, 1837: 38 (nec Leach, 1815: Crustacea), = *Repiucha* Francke, 1985: 12 nomen novum (syn. by Francke 1985: 12)

*Lychas* C. L. Koch, 1845: 1; Kræpelin, 1907: 184; L. E. Koch, 1977: 123; Francke, 1985: 9; Vachon, 1986: 835

*Lychas* [*sic*] Kræpelin, 1907: 193 (Francke 1985: 10)

*Lychas* [*sic*] Page, 1936: 13? (Francke 1985: 9)

*Lychas* [*sic*] Hadley, 1974 (Francke 1985: 9)

*Lychas* (*Hemilychas*) Hirst, 1911: 464 (syn. by L. E. Koch, 1977: 143)

*Lychas* (*Distotrichus*) Tikader & Bastawade, 1983: 4, (syn. by Vachon, 1986: 848)

*Lychas* (*Atherotrichus*) Tikader & Bastawade, 1983: 52 syn. n.

*Lychas* (*Endotrichus*) Tikader & Bastawade, 1983: 71 syn. n.

*Archisometrus* Kræpelin, 1891: 27 (syn. by Pocock 1900: 35)

*Archisometrus* [*sic*] Stålke, 1972: 128 (Francke 1985: 5)

TAXONOMIC POSITION. L. E. Koch (1977: 123) considered *Lychas* C. L. Koch, 1845 to be a synonym of *Isometrus* Hemphill & Ehrenberg, 1828 and 1829 (figured in 1828 and described in 1829). According to L. E. Koch (1977), the genus *Lychas* was described by C. L. Koch only in 1850.

It is true that C. L. Koch (1845) listed *Lychas maculatus* (= *Isometrus maculatus*) first, *Lychas americanus* (= *Isometrus maculatus*) second, and *Lychas scutellus* only third, although the latter was selected as the type species of the genus *Lychas* C. L. Koch, 1845 in accord with the rules of zoological nomenclature as then defined (Pocock, 1899: 834), and has been used as such since then (Pocock, 1900: 35; Vachon, 1985: 99; Vachon, 1986: 837). The taxonomic position of the genus *Lychas* has been worked out in detail by Vachon (1985).

The genus *Lychas* includes recently 34 species. Its vast distribution and attempts to better understand the relationships among the species have led to dividing the genus into several subgenera. Hirst (1911) erected the Australian subgenus *Hemilychas* with type species *L. (H.) alexandrinus* Hirst 1911. L. E. Koch (1977) compared Hirst's characters with other species of the genus and concluded that they do not justify subgeneric status.

Tikader & Bastawade (1983) divided *Lychas* into the subgenera *Distotrichus*, *Atherotrichus*, and *Endotrichus*. In discord with the international rules of zoological nomenclature, none of their subgenera has been named *Lychas*. The subgenera are differentiated on distribution of the trichobothria dt, db, et, and est (Figs 1 and 2, Tikader & Bastawade 1983: 4, Vachon 1986: 847, figs 22 - 24). This distinction was doubted by Vachon (1986), because the distribution of these trichobothria varies even intraspecifically. Fig. 2 shows the distribution of trichobothria on the tibia in a male of *Lychas mucronatus* from Thailand (Samut), which would be placed in the subgenus *Distotrichus*. Fig. 1 shows distribution of the pertinent trichobothria on the tibia

in a male of *Lychas mucronatus* from Thailand, prov. Kanchanaburi near river Kwai, which would be placed in the subgenus *Alloerotrachus* where the species was indeed placed by Tikader & Bastawade (1983). The figures make it clear that distribution of trichobothria dt, db, ct, and est cannot be considered a subgeneric character for the genus *Lychas*.

In the following checklist of the genus *Lychas* the species are ordered alphabetically

#### Checklist of the genus *Lychas* C. L. Koch, 1845

- albimanus* Henderson, 1919 India  
*alexandrinus* Hirst, 1911 Australia  
*Lychas myobergs* Kraepelin, 1916  
 = *Lychas truncatus* Glaue 1925  
 = *Lychas annulatus* Glaue 1925  
*asper* (Pocock, 1890) Congo, Zimbabwe, Tanzania, Mozambique  
*asper obscurus* (Kraepelin, 1916) Tanzania, Somalia, Zambia  
*biharensis* Tikader & Bastawade, 1983 India  
*braueri* (Kraepelin, 1897) Seychelles (Praslin Island)  
*burdai* (Simon, 1882) Tanzania, Kenya, Zimbabwe, South Africa, Congo, Zambia, Malawi  
 = ? *Lychas eritiae* Werner, 1916  
*burdai rhodesianus* Lawrence, 1938 Zimbabwe  
*burdai regulatus* Burula, 1913 Kenya  
*decorata* Basu, 1964 India  
*feae* (Thorell, 1889) Myanmar  
*flavimanus* (Thorell, 1888) Indonesia (Sumatra)  
*gracilis* Henderson, 1911 Myanmar  
*hendersoni* (Pocock, 1897) India  
 = *hasei* (Pocock, 1891) Malaysia (Sarawak)  
*infuscatus* (Pocock, 1891) Philippines  
*kamoharui* Tikader & Bastawade, 1983 India  
*kharradi* Bastawade, 1987 India  
*kuli* sp. n. Thailand  
*laevifrons* Pocock, 1897 India  
*marmoratus* (Koch, 1845) Australia, New Guinea  
 = *lymetrus tuberculatus* Pocock, 1891  
 = *Lychas marmoratus obscurus* Kraepelin, 1916  
 = *Lychas marmoratus nigrescens* Kraepelin, 1916  
 = *Lychas marmoratus splendens* Kraepelin, 1916  
 = *Lychas jutevae* Cuvier, 1925  
*mentawensis* Roewer, 1943 Sipora (Mentawai Island)  
*mucronatus* Fabricius, 1798; China, India, Myanmar, Thailand, Laos, Cambodia, Vietnam, Philippines, Malaysia, Indonesia  
 = *Scorpio curvifigitus* Gervais, 1844  
 = *Tropyx varius* C. L. Koch, 1845  
 = *lymetrus chinensis* Karsch, 1879  
 = *lymetrus atomarius* Simon, 1894  
*nigrimanus* Kraepelin, 1898; Indonesia (Sumatra)  
*nigritarsis* (Pocock, 1897) India  
*novifus* Basu, 1964 India  
*obesi* Kraepelin, 1916 Tanzania, Somalia, Kenya  
*perfidus* (Keyserling, 1887) Fiji (Viti Levu Island)  
*pupatus* (Pocock, 1897) India  
*rauber* Pocock, 1891 India

\* Kraepelin (1899) regarded *Lychas hasei* as a synonym of *Lychas flavimanus*, but according to Vachon & Lawrence (1985) it is a valid species



*lychnus* C.I. Koch, 1845 (type species of the genus) Myanmar, Thailand, Malaysia, Indonesia, introduced into Tanzania and Congo  
 = *Lychnus scutellatus* C.I. Koch, 1845  
 = *Isometrus weberi* Karnich, 1882  
 = *Isometrus mexstor* Simon, 1884  
 = *Isometrus rhaphsoni* Oates, 1888  
*serripes* Pocock, 1890: Mauritius (Round Island)  
*shelfordi* (Borelli, 1904): Malaysia, Indonesia (Kalimantan)  
*shopleandi* (Oates, 1888): Myanmar  
*tricarinatus* (Simon, 1884): India, introduced into West Africa (Slave Coast)  
*variatus* (Thorell, 1876): Australia, New Guinea  
 = *Isometrus thorelli* Keyserling, 1885  
 = *Isometrus variatus papuanus* Thorell, 1888  
 = *isometrus armatus* Pocock, 1890  
 = *Lychnus marmoratus timberleyanus* Kraepelin, 1916  
 = *Lychnus spinatus* Kraepelin, 1916  
 = *Lychnus spinatus brevis* Glauert, 1925  
 = *Lychnus spinatus pallidus* Glauert, 1925  
 = *Lychnus lupina* Glauert, 1954  
*tweedii* Kopstein, 1937: Malaysia

### *Lychnus králi* sp. n. (Figs 3-6, Table 1)

**TYPE MATERIAL.** Holotype - male and paratypes - 6 females (Nos 1-6) labelled Thailand, Umphang River, 16° 07' N 99° 00' E, 000 m above sea level, 28.IV-4.V.1991, leg. David Král & Vít Kubáň. Three females (Nos 7-9) labelled Thailand, Lansang, 16° 48' N 98° 37' E, 500 m above sea level, 18.-24.IV.1991, leg. David Král & Vít Kubáň. Two females (Nos 10 and 11) labelled Thailand, Chuang Dao Murs, 19° 25' N 98° 52' E, 17.-24.V.1991, leg. David Král & Vít Kubáň. One female (No. 12) labelled Thailand, 56 km NW of Chiang Mai, 19° 05' N 99° 25' E, 7.-14.VI.1993, leg. M. Snížek. Holotype and paratypes Nos 6-11, mounted dry, paratypes Nos 1-5 and 12 preserved in 75 % alcohol. Female No. 4 is deposited in the Department of Invertebrate Zoology, National Museum (Natural History), Prague. Holotype and all other paratypes are in the author's collection.

**TYPE LOCALITY.** Thailand, Umphang River, 16° 07' N 99° 00' E. Individuals rest under bark and in fissures and hollows of trees, and at night emerge on tree trunks and branches. At two localities (Lansang and 56 km NW of Chiang Mai) *Lychnus králi* sp. n. was found together with *Lychnus mucronatus*.

**ETYMOLOGY.** Named after the Czech entomologist David Král, who jointly with Vít Kubáň collected most of the type material.

**DESCRIPTION.** The total length is 35.2 mm in the male holotype and 30.4-39.8 mm in the female paratypes. The habitus is shown in Fig. 6. Measurements of the carapace, telson, segments of the maxilloma and segments of the pedipalps, and numbers of pectinal teeth are given in Table 1. There are 15 and 16 pectinal teeth in the male and 15-18 in the females. For the position and distribution of trichobothria on the pedipalps see Figs 3-5.

**Color.** The base color is yellow, with well marked black reticulation.

Cheilocera is more markedly reticulated in the anterior portion, whereas posteriorly the reticulation is subdued and faint. Carapace is without keels but with large granules. Color is more yellow and black spots farther apart. Present is a black spot around the median eyes, which is characteristic of the genus *Lychnus*. The margin of carapace has a black rim.

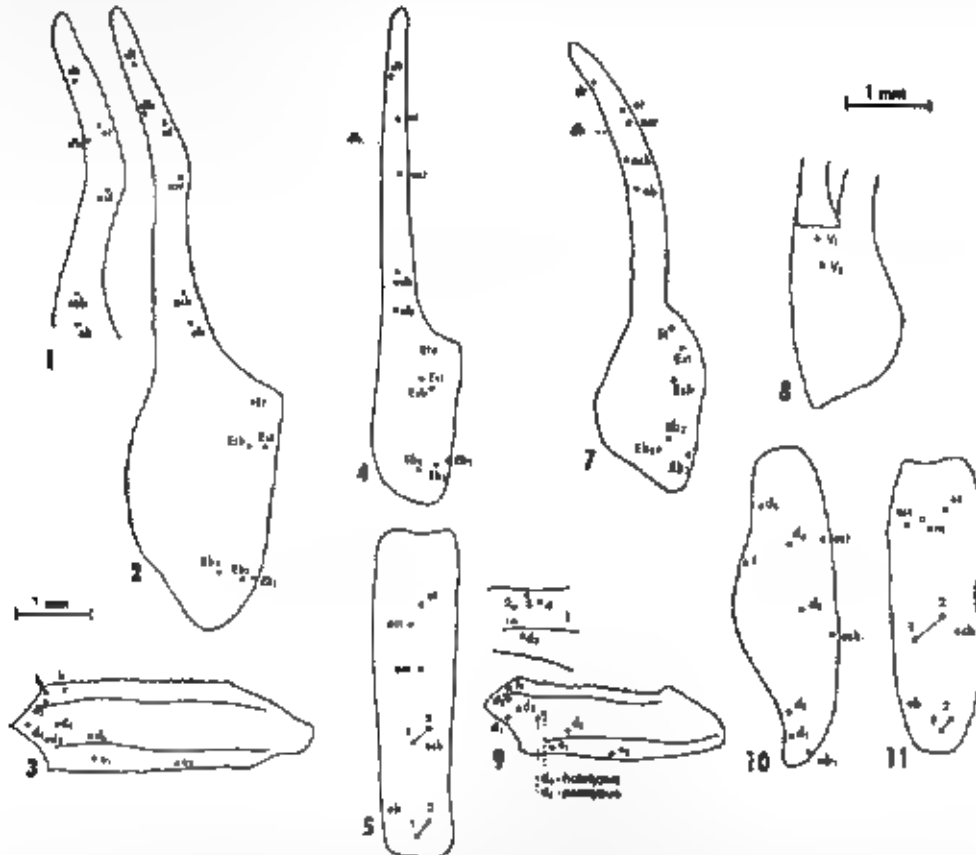
**Pedipalps.** Femur and patella are dorsally and laterally covered with dense black spots. Ventrally the spots have indistinct borders and colors blend more or less gradually. The lower and inner surfaces of the manus have dark spots in only some specimens (paratype No. 9), whereas in others (e.g. paratype No. 5) these surfaces are pale yellow. However, the dorsal and

lateral sides of the manus are as spotted as the patella. Fingers are light brown but darker than the manus.

The movable fingers of the pedipalps have 6 cutting edges. External lateral granules (Stahnke 1976: 303, No. 111) number 8 (Vachon 1986: 840, figs 2a and 4a).

Mesosoma is also spotted and becomes darker in older specimens. The hind margins of first through sixth segments each bear 6 nearly circular light yellow spots which are symmetrically distributed, with the second spot on each side always smaller than the others. The lower surface of the seventh segment bears 4 keels, but in some specimens only 2 are well developed and in others all the keels are barely discernible.

Legs have the same colors and patterns as the femur and patella of the pedipalps.



Figs 1, 5, 7-11 Fig. 1 *Lychas mucronatus* from Thailand (prov. Kanchanaburi, near river Kwai), Tibia Fig. 2 *Lychas mucronatus* from Thailand (Samut), Tibia Figs 3-5 *Lychas krai* sp. n. (holotype) Fig. 3 Femur Fig. 4 Tibia Fig. 5 Patella Figs 7-11 *Thacharmus mahunka* gen. n., sp. n. (holotype) Fig. 7 Tibia external Fig. 8 Tibia ventral Fig. 9 Femur Fig. 10 Patella dorsal Fig. 11 Patella ventral. Explanations: First letters: d, dorsal, e, external, i, internal. Second or second plus third letters: b, basal, sb, suprabasal, m, medial, st, subterminal, t, terminal. Numerals distinguish individual trichobothria of the same classification. Designation and description of trichobothria according to Vachon (1974). In Figs 2, 4, 7 and 8 the first capital letters denote trichobothria situated on the manus, the first lower-case letters (Figs 1, 3, and 7) denote trichobothria situated on the fixed finger of the pedipalp.

Tibial spur is present on the third and fourth pairs of legs and is well developed. Its size ranges from 0.21 to 0.25 mm on the third legs and from 0.26 to 0.32 mm on the fourth legs.

**Metasoma.** The segments of the metasoma are yellow to reddish brown. Black spots are less pronounced. The first and second segments bear 10 keels, the third and fourth segments bear 8 keels, and the fifth segment bears only 4 keels. The subaculcar tooth is pronounced, pointed, with one row composed of 2 granules in the upper midline and one granule at the tip.

**Affinities.** The described features distinguish *Lychas krati* sp. n. from all other species of the genus *Lychas*. Features separating the new species from others occurring in Thailand are given in the key below, whereas those separating it from species occurring in Myanmar, Malaysia, Indonesia, and the Philippines are discussed in the following paragraphs.

The length of adult specimens ranges between 30 and 40 mm and separates *Lychas krati* sp. n. from *L. hosei* from Borneo (62 mm, Pocock 1891), *L. tweediei* from the Malay Peninsula (67.5 mm, of which 37.5 mm is the metasoma, Kopstein 1937) and *L. mentawensis* from Sipora (57 mm, Roewer 1943). *Lychas krati* sp. n. differs from these 3 species also in the number of pectinal teeth, 20-21 in *L. hosei* (Pocock 1891), 18-20 in *L. tweediei* (Kopstein 1937), and 23 in *L. mentawensis* (Roewer 1943).

*Lychas nigrimanus* from Sumatra is 45 mm long and has 15-16 pectinal teeth, but whereas the first segment of the metasoma has 10 keels, the second through fourth segments have 8 keels (Kraepelin 1898). In *Lychas krati* sp. n. the second segment of the metasoma has 10 keels. Another difference is in coloration, *L. nigrimanus* having the femur and patella pale yellow, the manus dark, and the finger pale (Kraepelin 1899).

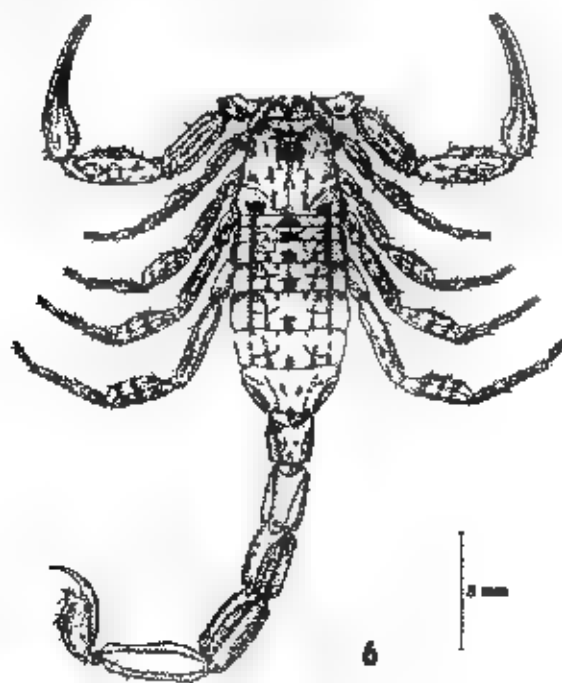


Fig. 6. *Lychas krati* sp. n. (paratype No. 4). Dorsal aspect.

Table 1. Measurements in millimeters of *Lychas krahl* sp. n. Line denoted "pectinal teeth" contains numbers of both left and right teeth separated by a colon

		<i>Lychas krahl</i> sp. n. holotype male	<i>Lychas krahl</i> sp. n. paratype (No. 5) female
Total	length	37.1	36.4
Carapace	length	4.7	5.3
	width	5	4.5
Metasoma	length	23.2	21.9
segment I	length	2.7	2.5
	width	2.3	2.3
segment II	length	3.3	3
	width	2	2
segment III	length	3.7	3.4
	width	1.9	1.9
segment IV	length	4.3	4.2
	width	1.8	1.9
segment V	length	5.3	5
	width	1.7	1.8
telson	length	4.2	3.8
Pedipalp			
femur	length	4.3	3.8
	width	1.2	1.1
patella	length	4.9	4.2
	width	1.7	1.6
tibia	length	7.5	6.5
manus	length	2.2	2.3
	width	1.3	1.2
finger movable	length	5.4	4.2
Pectinal teeth		16:15	16:16

*Lychas flavimanus* from Sumatra is about 42 mm long (Kraepelin 1899) and its coloration differs from *Lychas krahl* sp. n. The femur, patella, and finger of the pedipalps are black, and the manus is yellow or reddish brown (Kraepelin 1899).

*Lychas infuscatus* from the Philippines is about as long as *Lychas krahl* sp. n. but has only 10-11 pectinal teeth (Pocock 1900).

*Lychas shaplandi* from Myanmar differs from *Lychas krahl* sp. n. in having brownish yellow legs, chelicerae without spots, and 22 pectinal teeth (Oates 1888). Pocock (1900) emphasized its long tibial spur.

*Lychas graveolus* has only 2 pectinal teeth (Tikader & Bastawade 1983) and differs in coloration (Tikader & Bastawade 1983: 48), e. g. the metasoma is dark brown to black in contrast to yellow or reddish brown in *Lychas krahl* sp. n. Another difference is in the position of trichobothria d5 and e1 on the femur of the pedipalp and trichobothria on the patella of the pedipalp (Figs 3, 5, and Tikader & Bastawade 1983: 51, figs 125, 127). This species which

occurs in Myanmar and Tikader & Bastawade (1983) do not exclude the possibility of its presence also in India, is the one most similar to *Lychas krahl* sp. n.

*Lychas fede* from Myanmar was characterized by Pocock (1900) as having a long tubial spur and black manus, carapace, and terga. The legs are usually also black. The fingers are yellow according to Pocock (1900) but black according to Kraepelin (1899).

### *Lychas macronotus* (Fabricius, 1798) (Figs 1-2)

*Scorpio macronotus* Fabricius, 1798: 294.

*Styus macronotus* C. L. Koch, 1845: 29.

*Isometrus macronotus* Simon, 1884: 363. Thorell, 1889: 566. Pocock, 1894: 85.

*Archimetopus macronotus* Kraepelin, 1899: 46. Pocock, 1894: 85. Wu, 1936: 117.

*Lychas macronotus* Pocock, 1900: 96; Werner, 1935: 271. Vachon & Ahe, 1988: 16.

*Lychas* (*Allotrichus*), *macronotus*: Tikader & Bastawade, 1983: 53.

? *Scorpio armillatus* Gervais, 1844: 48 (syn. by Kraepelin, 1891: 223).

*Scorpio curvicaudatus* Gervais, 1844: 48 (syn. by Thorell, 1893: 368).

*Archimetopus curvicaudatus* Kraepelin, 1891: 223.

*Styus varius* C. L. Koch, 1845: 29 (syn. Thorell, 1889: 566).

*Isometrus varius* Simon, 1884: 362.

*Isometrus chinensis* Karsch, 1879: 116 (syn. by Kraepelin, 1891: 223).

*Isometrus atomarius* Simon, 1884: 363 (syn. by Kraepelin, 1891: 223).

**MATERIAL.** Thailand, Chiang Mai, 15 VI 1987, 2 females, leg. C. M. Brändsletter, Kanchanaburi prov. Kanchanaburi near river Kwai, 5.IV.1991, 2 males, 3 females, 1 juv. leg. J. Fackel, Lansang, 16° 48' N 98° 57' E, 500 m above sea level, 18-24.IV.1991, 1 female, leg. D. Král & V. Kubán, Palong near Fang, 19° 55' N 99° 06' E, 750 m above sea level, 27.V.1991, 1 male, 2 females, leg. D. Král & V. Kubán, Samut, 1 male, 12.II.1993 [collector unknown], Sai Buri, 23-27.IV.1993, 3 females, leg. J. Simadi, Mae Hong Son, Nupa Ah, 30.VI.1993, 1 male, 9 females, leg. J. Schneider, Chiang Dao env. 21.V.4.VI.1995, 1 male, 2 females, leg. M. Snížek, 56 km NW of Chiang Mai, 19° 05' N 99° 25' E, 7-14.VI.1995, 6 females, 22 juvs before 1st ecdysis, leg. M. Snížek, Vietnam, Saigon, 1988, 1 male, 1 immature female, leg. Janka, near Binh-Chan, 23.IV.1989, 1 female, leg. M. Snížek, Hanoi, X. XI.1991, 13 males, 22 females, leg. R. Hanzal, in the author's collection. Malaysia, Bali [collector unknown], 1 male deposited in the Department of Invertebrate Zoology, National Museum (Natural History), Prague. Laos, Dong Doh, 20.III.1990, 1 juv. after 3rd ecdysis, leg. Kondrosov, deposited in the Department of Zoology, Magyar Természettudományi Museum in Budapest.

**COMMENTS.** *Lychas macronotus* was characterized by Roewer (1943) as having 10 keels on the second caudal segment, 2 keels on the underside of the seventh segment of the mesosoma, total length of 50-58 mm, and 21 pectinal teeth. Pocock (1900) gave a total length of 58 mm for the female and 53 mm for the male, and also about 21 pectinal teeth.

Upon examination of a number of specimens I found the keels on the underside of the seventh segment of the mesosoma to be often indistinct, indicated only by several widely spaced granules.

The largest specimens in my collection come from Thailand (Chiang Dao) and are about 55 mm (female) and 62 mm (male) long. Females from Nupa Ah are about 57 mm long. Other specimens from Thailand range from 45 to 50 mm in length. Only one female from Lansang is 40 mm long. Specimens from Vietnam (Hanoi) are 43-55 mm (female) and 43-53 mm (male) long. A small immature male from Saigon is 35 mm long.

There are usually 21 and rarely 23 pectinal teeth in the males and 19-22 (most frequently 20) in the females. Only one female from Vietnam (Hanoi) has 18 pectinal teeth and a female from Lansang (Thailand) has 19 and 24 pectinal teeth.

**DISTRIBUTION.** China (Wu 1936: 117), India, Cambodia (Tikader & Bastawade 1983: 60), Myanmar (Kraepelin 1913: 132), Thailand (Vachon & Ahe 1988: 26), Laos (Page, 1933: 26),

Philippines (Vachon & Abe 1988: 26), Malaysia (Fage, 1933: 26), and Indonesia (Kraepelin 1899: 47). This species is recorded for the first time from Vietnam. In Thailand it is the dominant species of scorpion.

*Lychas scutellus* C. L. Koch, 1845

*Lychas scutellus* C. L. Koch, 1845: 3; Pocock, 1900: 37.  
*Isometrus scutellus*: Pocock, 1891: 435.  
*Lychas scutellus* C.L. Koch, 1845: 163 (syn. by Pocock, 1900: 37).  
*Archisometrus scutellus*: Kraepelin, 1899: 44.  
*Isometrus weberi*: Karsch, 1882: 84 (syn. by Pocock, 1891: 435).  
*Isometrus messor*: Simon, 1884: 371 (syn. by Pocock, 1891: 435).  
*Isometrus phippanti*: Oates, 1888: 248 (syn. by Pocock, 1891: 435).

**MATERIAL.** Thailand, Betong, 4 males, 6 females, IV 1993, leg. J. Simad & J. Horák; Malaysia, Pangkor Island, 2 females, 5 II 1995, leg. S. Bečvář; Kedah, Langkawi Island, 1 male, 4 females, 1 juv. 15-17 VI 1995, leg. S. & E. Bečvář in the author's collection.

**COMMENTS.** Length was given by Roewer (1943) as 65 mm and by Pocock (1900) as 65 mm (metasoma 37) in the female and 81 mm (metasoma 57) in the male. According to Roewer (1943) there are 16 and more pectinal teeth.

Males from Thailand (Betong) are 62 mm (metasoma 43 mm) to 85 mm (metasoma 60 mm) long and females are 48 mm (metasoma 28 mm) to 65 mm (metasoma 39 mm) long. There are 16-19 pectinal teeth in the males and 16-17 in the females.

Males from Malaysia (Kedah), are 71 mm (metasoma 49 mm) long and females are about 60 mm (metasoma 35 mm) long. There are 19 pectinal teeth in the males and 15-18 in the females.

On the underside of the seventh segment of the mesosoma are 4 pronounced keels. The second segment of the metasoma has 8 keels.

**DISTRIBUTION.** Myanmar, Thailand, Malaysia, Indonesia. Introduced into Tanzania and Congo (Kraepelin 1899: 45). In Thailand and Myanmar this species appears to be confined to the southern regions.

*Thaicharmus* gen. n. (Figs 7-17, Table 2)

**TYPE SPECIES.** *Thaicharmus mahunkai* sp. n.

**ETYMOLOGY.** Denotes affinity to the genus *Charmus* and the geographic distribution.

**DESCRIPTION.** A combination of characters differentiates this genus from all other genera of the family Buthidae. The basic trichobothria pattern is alfa (Fig. 9 and Sissom 1990: 70, fig. 33), legs III and IV have well developed tibial spurs (Fig. 16), the sternum is subpentagonal (Fig. 13), and the pedipalp manus has 3 lb trichobothria on the palm (Fig. 7). This complex of characters is exhibited only by the genera *Butheoloides* Hirst, 1925 from northern Africa and *Charmus* Karsch, 1879 from India and Sri Lanka (Sissom 1990: 94). *Thaicharmus* gen. n. shares with *Butheoloides* telson with subacicular tubercle and with *Charmus* a similar habitus (Fig. 12), similar proportions, the same structure of lateral eyes, and coloration, many other similar but also differing features can be seen on the metasoma.

*Thaicharmus* gen. n. is also characterized by the number and distribution of trichobothria on the pedipalps (Figs 7-11), chiefly by a shift of trichobothrium em toward trichobothria est and ct (Fig. 11, and Vachon 1974, fig. 24), 12 (including apical row) cutting edges on the movable

fingers of pedipalps (Fig. 17), and other features included in the description of *Thaicharmus mahunkai* sp. n. below.

**AFFINITIES.** The most closely related genus *Charmus* is easily distinguished from *Thaicharmus* gen. n. by having only 8 cutting edges on the movable fingers of pedipalps, by the absence of subaculear tubercle on the telson, and by the distribution of trichobothria on the pedipalps, chiefly the position of trichobothria em, est, and et on the patella (Fig. 11 and Sreenivasa Reddy 1966: fig. 3, Vachon 1982: fig. 5, and Tikader & Bastawade 1983: figs. 393, 413). The fifth segment of the metasoma terminates in a pronounced, broad process that overlaps the telson (Fig. 12). This process is absent in both *Charmus* and *Butheoloides*.

The genus *Butheoloides* is easily distinguished from *Thaicharmus* gen. n. by having 9 (including apical row) cutting edges on movable fingers of pedipalps (Vachon 1950: 173) and by the distribution of trichobothria on the pedipalps, chiefly position of the above noted trichobothria em, est, and et on the patella (Fig. 11 and Vachon 1950: fig. 2). The genus *Butheoloides* occurs in Morocco, Senegal, Mauretania, Republic of Mali, and Ivory Coast.

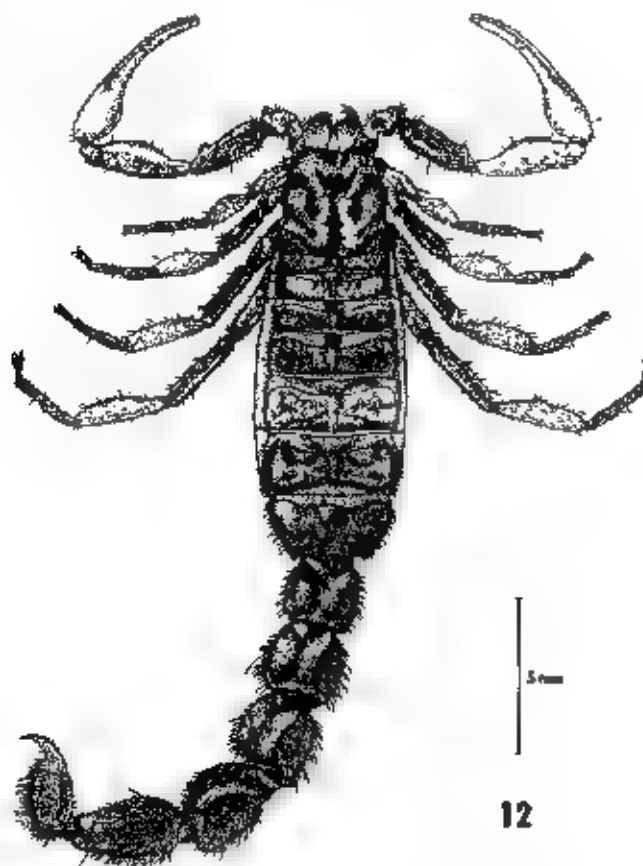


Fig. 12 *Thaicharmus mahunkai* gen. n., sp. n. (holotype, Dorsal aspect)

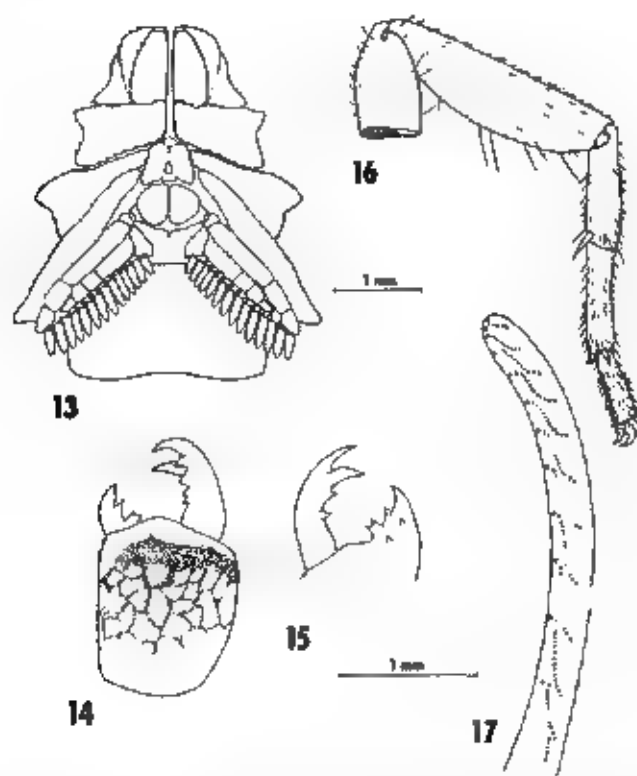
*Thaicharmus* gen. n. differs from other scorpion genera occurring in Thailand by features given in the key below. Inclusion in the key of genera of the family Buthidae in Sissom (1990: 94) is as follows:

- Pedipalp chela with 9 Eb trichobothria on palm:  
 Telson with distinct subaculear tubercle, carapace granular but lacking distinct carinae ..... 1  
 Telson lacking subaculear tubercle, carapace possessing distinct carinae ..... *Charmus*  
 1 Cutting edges of movable fingers of pedipalps number 9 (including apical row) ..... *Buthusoides*  
 - Cutting edges of movable fingers of pedipalps number 12 (including apical row) ..... *Thaicharmus* gen. n.

*Thaicharmus mahunkai* sp. n. (Figs 7-17, Table 2)

**TYPE MATERIAL.** Holotype and paratype - 2 females preserved in 75% alcohol, labelled: Thailand, Kaeng Krachan (Phetchaburi), Kaeng Krachan National Park, Reservior, 7 II. 1994, leg. Mahunka Sándor & L. Mahunka-Papp. Locality No. 59 in Mahunka & Mahunka (1994: 267). The holotype is deposited in the Department of Zoology, Magyar Természettudományi Museum in Budapest. The paratype is in the author's collection.

**TYPE LOCALITY.** Thailand, Kaeng Krachan (Phetchaburi), Kaeng Krachan National Park. Collected under rocks.



Figs 13-17 *Thaicharmus mahunkai* gen. n., sp. n. (holotype). Fig. 13 Ventral aspect, Fig. 14 Cheliceræ dorsal, Fig. 15 Cheliceræ ventral, Fig. 16 Fourth right leg, Fig. 17 Cutting edges of movable fingers.



**ABSTRACT.** Differential diagnosis of the new species is included in the generic diagnosis, and differentiation from other Thai scorpions can be found in the key below.

**ETYMOLOGY.** Named after Sándor Mahunka (Magyar Természettudományi Museum in Budapest), who collected the type material.

**DESCRIPTION.** The length is 28.9 mm in the holotype and 29.2 mm in the paratype. The habitus is shown in Fig. 12. Measurements of the carapace, telson, segments of metasoma and segments of pedipalps, and numbers of pectinal teeth (Fig. 13) are given in Table 2. There are 14 and 15 pectinal teeth in the holotype and 14 in the paratype. For the position and distribution of trichobothria on the pedipalps see Figs 7-1.

**COLOR.** The base color is black. Femur of pedipalp is black, patella of pedipalp is light brown of varying shade, manus of pedipalp is pale yellow, and both fingers are light brown but darker than the manus.

**Chelicerae** (Figs 14, 15) are yellow, with black reticulation which is better defined in the anterior third.

Table 2. Measurements in millimeters of *Thaicharmus mahunkai* gen. n. sp. n.. Line denoted "pectinal teeth" contains numbers of both left and right teeth separated by a colon.

		<i>Thaicharmus mahunkai</i> sp. n.	<i>Thaicharmus mahunkai</i> sp. n.
		holotype	paratype
Total	length	28.9	29.2
Carapace	length	3.5	3.4
	width	3.5	3.4
Metasoma	length	16.5	16.2
segment I	length	2.3	2.2
	width	2.5	2.4
segment II	length	2.7	2.3
	width	2.5	2.4
segment III	length	2.7	2.5
	width	2.5	2.4
segment IV	length	2.9	2.6
	width	1.5	2.4
segment V	length	3.7	3.4
	width	2.5	2.4
Telson	length	3.3	3.2
Pedipalp			
femur	length	3	2.8
	width	0.9	0.9
patella	length	3.6	3.6
	width	1.3	1.2
tibia	length	5.6	4.9
manus	length	2	1.8
	width	1.2	1.2
finger movable	length	3.6	3.1
Pectinal teeth		14/15	14/14

Carapace is black, without keels, and granulated. The granulation is subdued in the anterior portion and around median eyes. In the posterior portion are two larger, oval, symmetrically situated elevated areas separated by a median groove. Four pairs of lateral eyes are situated in a row near the carapace margin.

Legs are pale yellow except for the femur which is always dark gray to black and the patella whose part adjacent to the femur is deep to dark yellow. Most legs have faint black spots on the inner sides. Legs III and IV have well developed tibial spurs (Fig. 16).

Mesosoma has only one median keel. The tergites of the mesosoma are black with a yellowish-brown pattern.

Metasoma is black and telson is reddish brown. The segments of the metasoma have only two dorsal keels which are well developed but sparsely granulated. Only in the anterior portions of the keels on segments 3-5 is a row of several irregular granules which are larger on the fourth and largest on the fifth segment. There are 4 such granules on the third segment, 5 on the fourth segment, and 6 on the fifth segment. The dorsal keels are separated by a median groove which is granulated and black, in contrast to the lateral areas which are brown. In all segments the groove opens anteriorly to form a ledge that takes the entire segment width, whereas on the posterior margins the widening of the groove is at first minor and gradually attains a larger area caudad. On the fifth segment this area takes one-half of the surface and its granulation diminishes toward the posterior margin. The lateral and ventral parts of the segments are rounded, lack keels, and are sparsely pitted. Pits are present also on the telson, which has a small and blunt subaculear tubercle located below the aculeus. The fifth segment of the metasoma terminates in a large, broad process that partially overlaps the telson (Fig. 12). The metasoma is sparsely covered with hairs which are longer on the sides and ventrum than on the dorsum. The ventral surface of the telson is more densely hirsute than the preceding segments.

#### *Scorpiops (Scorpiops) farkaci* Kovarik, 1993

*Scorpiops (Scorpiops) farkaci* Kovarik, 1993: 111

**MATERIAL.** Thailand, prov. Mae Hong Son, Ban Hui Po, 1600-1700 m above sea level, 3 males, 6 mature females, 4 immature females, 4 juvs before the first ecdysis, 2 juvs after the first ecdysis, 9 juvs after the second ecdysis (holotype, paratypes nos. 1-27), 10 V 1991, leg. J. Farkac. Female no. 4 is deposited in the Department of Invertebrate Zoology, National Museum (Natural History), Prague. Holotype and all other paratypes are in the author's collection.

**COMMENTS.** This species is known only from the type material collected in a xeric clearing of a virgin mountain forest at elevations 1600-1700 m; all specimens were found beneath dry buffalo faeces.

#### *Scorpiops (Euscorpiops) binghami* Pocock, 1893

*Scorpiops binghami* Pocock, 1893: 327, Pocock, 1900: 74

*Scorpiops longimanus binghami* Kraepelin, 1913: 161

*Scorpiops longimanus binghami* Vachon, 1974: 942

*Scorpiops (Euscorpiops) longimanus binghami* Vachon, 1988: 155

*Scorpiops (Euscorpiops) binghami* Tikader & Bastawade, 1983: 470

*Scorpiops (Euscorpiops) binghami* Kovarik, 1993: 113

**MATERIAL.** Thailand, Mae Hong Son distr., Napa-ah, 1 immature female, 7-9 V 1992, leg. J. Stenad, in the author's collection.

COMMENTS. This specimen has 19 trichobothria on the external surface of the patella (5 eb, 2 esb, 2 em, 5 est, 5 et), 9 pectinal teeth, and 13 trichobothria on the lower surface of the patella. Vachon (1974 and 1980) regarded this species as a subspecies of *Scorpiops (Euscorpiops) longimanus*. Kraepelin first (1899-190) considered it a synonym of *Scorpiops montanus* Karsch, 1879, but in 1913 placed it as a subspecies in *Scorpiops longimanus*.

*S. (E.) binghami* has been known from Tenasserim Mts. (Myanmar). Its discovery in Thailand (Kovářík 1993) therefore is not surprising.

*Scorpiops (Euscorpiops) longimanus* Pocock, 1893 (Figs 18-19)

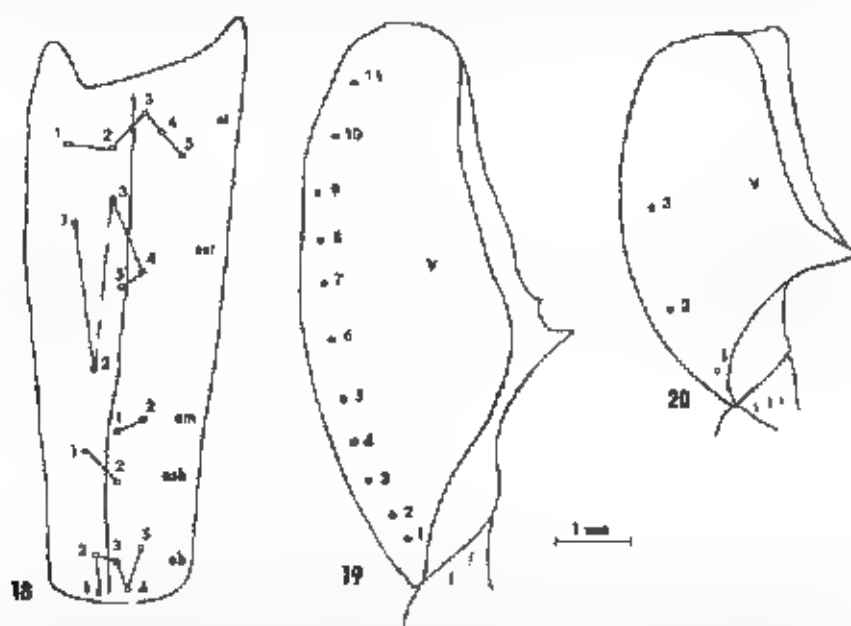
*Scorpiops longimanus* Pocock, 1893: 326, Kraepelin, 1894: 91, Kraepelin, 1899: 180, Pocock, 1900: 72, Kraepelin, 1913: 160.

*Scorpiops (Euscorpiops) longimanus longimanus* Vachon, 1980: 153.

*Scorpiops (Euscorpiops) longimanus* Tikader & Bustawade, 1983: 464, Kovářík, 1993: 113.

MATERIAL. Thailand, prov. Chiang Mai, Doi Suthep, Phu., male, ♀, female, 20.IV.1991, leg. J. Farkas; Doi Chiang Dao, 800 m above sea level, 1 juv., ♀, 1991, leg. D. Král & V. Kubík, in the author's collection.

COMMENTS. These specimens have 19 trichobothria on the external surface of the patella (5 eb, 2 esb, 2 em, 5 est, 5 et) (Fig. 18), and 11 or 12 trichobothria on the lower surface of the patella (Fig. 19). Tikader & Bustawade (1983) found 10 or 11 trichobothria on the lower surface of the patella in specimens from India. Pectinal teeth number 6-8.



Figs. 18-20. Figs 18-19 *Scorpiops (Euscorpiops) longimanus* from Thailand. Fig. 18 Patella external, Fig. 19 Patella ventral, Fig. 20 *Euscorpiops longimanus* from Thailand Patella ventral. Explanations: First letters: e, external, v, ventral. Second or second plus third letters: b, basal, sb, suprabasal, st, subterminal, t, terminal. Numerals distinguish individual trichobothria of the same classification. Designation and description of trichobothria according to Vachon (1974).

This species is known from India, Bangladesh (Tikader & Bastawade 1983: 470) and Thailand (Kováčik 1993: 113). It is therefore likely that it occurs also in Myanmar.

### *Liocheles* Sundevall, 1833

*Scorpio* (*Liocheles*) Sundevall, 1833: 31

*Sisyphus* [sic] C. L. Koch, 1837: 37 (L. E. Koch, 1977: 160; Francke, 1985: 13).

*Ischnurus* C. L. Koch, 1837: 37 (syn. by Thorell, 1876: 251; Francke, 1985: 9).

*Hormurus* Thorell, 1876: 14 (syn. by Karsch, 1880; Francke, 1985: 9).

**TAXONOMIC POSITION** Sundevall (1833) described the genus *Liocheles* as a subgenus with the type species *Scorpio australasiae* Fabricius, 1775. C. L. Koch (1837) described the genus *Ischnurus* with the type species *Sisyphus* [lapsus calami = *Ischnurus*] *complanatus* C. L. Koch, 1837 (= *Liocheles australasiae* Fabricius, 1775). Even recent publications (e. g. Tikader & Bastawade 1983: 499) often incorrectly use the generic name *Hormurus* erected by Thorell (1876) with the type species *ischnurus caudicula* L. Koch, 1867 (= *Liocheles waigiensis* (Gervais, 1844)).

### *Liocheles australasiae* (Fabricius, 1775) (Fig. 20)

*Scorpio australasiae* Fabricius, 1775: 399; Fabricius, 1793: 433.

*Scorpio* (*Liocheles*) *australasiae* Sundevall, 1833: 31.

*Ischnurus australasiae* C. L. Koch, 1837: 7.

*Hormurus australasiae* Thorell, 1876: 251. L. Koch, 1885: 22; Thorell, 1888: 419; Pocock, 1894: 96; Simon, 1893: 328; Thorell, 1894: 1; Kraepelin, 1894: 133; Kraepelin, 1897: 1; Kraepelin, 1899: 154; Simon, 1899: 120; Pocock, 1900: 79; Kraepelin, 1901: 272; Werner, 1902: 503; Kraepelin, 1913: 163; Kraepelin, 1914: 328; Werner, 1916: 91; Kopsch, 1921: 135; Kopsch, 1923: 185; Kopsch, 1926: 111; Giltay, 1931: 9; Page, 1933: 27; Wu, 1936: 121; Tikader & Bastawade, 1983: 50.

*Liocheles australasiae* Simon, 1887: 13; Takashima, 1945: 95; Takashima, 1948: 86; Takashima, 1950: 17; L. E. Koch, 1977: 160; Vachon & Ahe, 1988: 27.

*Hormurus australasiae suspectus* Thorell, 1888: 419; Kraepelin, 1899: 154; Kraepelin, 1913: 163 (syn. by L. E. Koch, 1977: 161).

*Ischnurus complanatus* C. L. Koch, 1837: 73 (syn. by Thorell, 1876: 254).

*Scorpio gracilicauda* Cuvier-Ménéville, 1843: 1 (syn. by Kraepelin, 1899: 154).

*Scorpio cumingi* Gervais, 1844: 69 (syn. by Kraepelin, 1899: 154).

*Ischnurus pinavensis* Simon, 1877: 93 (syn. by Kraepelin, 1899: 154).

*Buthus brevicaudatus* Rainbow, 1897: 107 (syn. by Kraepelin, 1899: 154).

*Hormurus boholensis* Kraepelin, 1914: 333 (syn. by L. E. Koch, 1977: 161).

*Hormurus caudicula boholensis* Giltay, 1931: 12 (syn. by L. E. Koch, 1977: 161).

**MATERIAL** **Thailand**, prov. Mae Hong Son, Ban Huai Ph. 1600 m above sea level, 1 female, 0 V 1991, leg. J. Farkaš. prov. Mae Hong Son, Ban Si Lang, 1600-2000 m above sea level, 1 male, 17-23 V 1991, leg. J. Horák. Doi Chuang Dao Mts., 9° 25' N 98° 52' E, 1000 m above sea level, 17-24 VI 1991, 1 female, leg. D. Král & V. Kabáň. prov. Mae Hong Son, Huai Sue Tao, 1 male, 1 female, 11.-17 V 1992, leg. J. Strnad. Betong, 2 males, 3 females, IV 1993, leg. J. Horák & J. Strnad. **Vietnam**, Ha Long, 1 female, 6-7 XI 1988, leg. S. Bečvář in the author's collection, 18 km S of Da Lat, 19 X 1988, 2 females, 1 juv., leg. Mahunka & Vášárhelyi (Locality No. 332), 35 km NE of Ban Loc, Tung Rieng River, 23 X 1988, 1 female, 3 juvs., leg. Mahunka & Vášárhelyi (Locality No. 306), Ban Loc, 27 X 1988, 1 female, 1 juv., leg. Mahunka & Vášárhelyi (Locality No. 402), in the Department of Zoology, Magyar Természettudományi Múzeum in Budapest. **Malaysia**, Cameron Highlands, 36 females, 18 males, 1992, collector unknown, Perak Taiping, 3 juvs., 1 I 1995, leg. S. Bečvář; Kedah, Langkawi Island, 1 female, 15-17 VI 1995, leg. S. & E. Bečvář. **Sarawak**, Kuching, 2 males, 7 females, 14 juvs., 9-20 III 1994, leg. P. Bilek. **Sarawak**, Rumah Ugan, 14 juvs., 3 ♀ III 1994, leg. P. Bilek. **Indonesia**, Borneo, Nanga Sarawak env., Tontang, 1 female, 24 VII-2 VIII 1993, leg. J. Schneider, in the author's collection.

**COMMENTS** According to Vachon & Abe (1988) this is a small scorpion not exceeding 30 mm in total length. Specimens from the Malay Peninsula (Cameron Highlands) reach only 22-26 mm. A female from Malaysia (Kedah) is 33 mm long, and a female from Vietnam is 29 mm long. The largest female in the author's collection, 33.5 mm long, is from Thailand (Ban Huai Po).

The largest specimens, 35 mm, are recorded by L. E. Koch (1977) from Australia. Wu (1936) recorded lengths of 26-31 mm from China.

The number of pectinal teeth is given by Vachon & Abe (1988) as 4-7, by Wu (1936) as 6, and by L. E. Koch (1977) as 8-9 in the male and 4-8 in the female. A female from North Vietnam (Ha Long) has, like most other specimens from Thailand, 6 pectinal teeth. Only the largest female from Thailand (Ban Huai Po) has 4 and 5 pectinal teeth.

Details on South Vietnam localities (Nos 332, 366, and 402) can be found in Mahunka, Oláh & Vászárhelyi (1989).

**DISTRIBUTION** China, Korea, India, Myanmar, Thailand, Cambodia, Laos, Vietnam, Philippines, Malaysia, Indonesia, Polynesia, Micronesia, and Australia (e.g. L. E. Koch 1977: 161; Tikader & Bastawade 1983: 505, Page 1933: 27).

The species has been so far recorded for Vietnam only by L. E. Koch (1977), from southern South Vietnam. The new specimens introduced here are from North Vietnam.

#### *Locheles nigripes* (Pocock, 1897)

*Hormurus nigripes* Pocock, 1897: 117; Kraepelin, 1899: 155; Pocock, 1900: 80; Kraepelin, 1913: 163; Page, 1944: 72; Tikader & Bastawade, 1983: 506.

**COMMENTS** This species is known from India (Pocock 1900; Tikader & Bastawade 1983) and Laos (Page 1944). It is therefore reasonable to assume its presence also in Myanmar, Thailand, and Cambodia.

Scorpionidae Peters, 1862

#### *Heterometrus (Heterometrus) laoticus* Couzijn, 1981

*Heterometrus (Heterometrus) laoticus* Couzijn, 1981: 88.

**MATERIAL** Thailand, Ban Sach near Chonburi, 1 immature male, 3 VI 1991 leg. D. Král & V. Kubaň, breeding F. Kovářik, 6th ecdysis 12 X 1991; Khorat, 180 km NE of Bangkok (purchase from Bangkok), 4 males, 3 females, V 1991, 3 males, 3 females, V 1994. Cambodia, Takeo, 1 female, 1984, in author's collection.

**COMMENTS** Couzijn (1981) gave the length of both sexes as up to 117 mm. Specimens purchased from Bangkok are 88-122 mm long. In contrast to most other species of *Heterometrus* there is no apparent difference between the male and female in the shape and size of the pectipalps.

**DISTRIBUTION** Vietnam, Laos, Cambodia, Thailand (Couzijn 1981: 94). Couzijn (1981) regarded this species as common in Laos and more rare in Thailand, Cambodia, and South Vietnam. For Thailand he recorded only one male from Siam. However, *H. laoticus* must be quite common at suitable localities around Bangkok, because in the city it is sold to tourists in large numbers, with dozens of specimens crowded in each container. Unfortunately only one immature male has been so far collected in nature, from a dry cultivated field.

***Heterometrus (Heterometrus) spinifer spinifer* (Hemprich & Ehrenberg, 1828)**

*Buthus (Heterometrus) spinifer* Hemprich & Ehrenberg, 1828 pl. 1 fig. 2 Hemprich & Ehrenberg, 1829 352  
*Heterometrus (Heterometrus) spinifer spinifer* Couzijn, 1981 89  
*Palaemonetes longimanus* Thorel, 1876: 221 (syn. by Couzijn, 1981: 89)  
*Heterometrus longimanus* (part): Kraepelin, 1894 4., 1899: 111, Gilkey, 1931 4, Takashima, 1945 90 (Couzijn, 1981: 89).  
*Palaemonetes outesi* Pocock, 1900: 98, Gilkey, 1931 4, Takashima, 1945: 94 (syn. by Couzijn, 1981: 89).

**MATERIAL.** Thailand: Betong, 1 male, IV.1993, leg. J. Sornrad; Trang-Kao Cong, 1 juv., 10.IX.1993, leg. Veselý; Thaleban, 30 km SW of Satun, 1 male, 20.IX.1993. Malaysia, Cameron Highlands, 4 females, 2 juvs., 1992; Jalawang jungle near Dabong, 1 female, 29.VI.1995, leg. S. Bečvář; Pahang/Johor, Endau Rompin n. park, Seladang, 100 m above sea level, 1 male, 28.II-12.III.1995, leg. M. Štúr & R. Hergovits, in author's collection.

**COMMENTS.** According to Couzijn (1981), females reach lengths up to 125 mm. The above listed males from Thai. and are 1-5 mm long. Couzijn (1981) described also the subspecies *H. spinifer suttaricus* from Sri Lanka.

Because of the differences between specimens from Malaysia (Cameron Highlands) and Thailand, chiefly in the shape of the manus of pedipalps, it is likely that the subspecific taxonomy will need to be further modified. More material from diverse localities is needed, however, for such studies to commence.

**DISTRIBUTION.** South Vietnam, Cambodia, Thailand, Malaysia.

In Thailand the species apparently occurs only in the south, and in Malaysia it has been recorded only from the mainland. It is absent in Borneo.

**Key to species of Scorpionida from Thailand**

- |   |   |   |
|---|---|---|
| A. Juvenile black specimen over 10 cm long  | <i>Heterometrus</i>                           | 1 |
| - Total length up to 9 cm   |   | 2 |
| 1. Manus slightly longer than wide. Surface of manus nearly smooth, without keels. Patella and femur of pedipalps the same in males and females. Telson black   | <i>Heterometrus loricatus</i>                 |   |
| Manus much longer than wide. Surface of manus with keels. Patella and femur longer in male than in female. Telson often pale yellow   | <i>Heterometrus spinifer spinifer</i>         |   |
| 2. Pedipalp femur with 10 or more trichobothria, of which 4 or 3 are on the internal aspect (Fig. 9). Telson with subaculear tooth (Fig. 6) or tubercle (Fig. 12)   | <i>Buthidae</i>                               | 3 |
| Pedipalp femur with 9 or fewer trichobothria, of which only 1 is on the internal aspect. Telson without subaculear tooth or tubercle  |   | 8 |
| 3. Telson with a small, blunt subaculear tubercle (Fig. 12). Cutting edges of movable fingers of pedipalps number 12 (including apical row - Fig. 17)   | <i>Theraphosus malabaricus</i> gen. n. sp. n. | 4 |
| - Telson with a pointed subaculear tooth (Fig. 6). Cutting edges of movable fingers of pedipalps number 6   |   | 5 |
| 4. Tibial spur (Fig. 16) present on legs III and IV   | <i>Lychas</i>                                 | 5 |
| Legs without tibial spur  | <i>Isometrus</i>                              | 7 |
| 5. Second segment of metasoma with 8 keels. Ventral surface of seventh segment of mesosoma with 4 keels. Legs, pedipalps, and metasoma without spots. Metasoma much longer in male than in female. Telson in male very long and slender | <i>Lychas scutellatus</i>                     |   |
| Second segment of metasoma with 10 keels. Legs and pedipalps spotted (Fig. 6). Metasoma of approximately the same length in both sexes  |   | 6 |
| 6. Total length 40-40 mm. Pectinal teeth number 15-18. Manus of pedipalps of the same color as patella and femur of pedipalps   | <i>Lychas krali</i> sp. n.                    |   |
| Total length 40-60 mm. Pectinal teeth number 18-24 (most frequently 20-21). Manus of pedipalps bright yellow with sparse, minute black spots  | <i>Lychas murronatus</i>                      |   |
| 7. Total length 40 mm or more. Pectinal teeth number 17-19  | <i>Isometrus malabaricus</i>                  |   |
| Total length 23 mm. Pectinal teeth number 12-13   | <i>Isometrus vittatus</i>                     |   |

- 8 Number of trichobothria on the lower surface of the patella is 9-13 (Fig. 19) *Scorpiops* 9  
 - Number of trichobothria on the lower surface of the patella is 3 (Fig. 20) *Locheles* 11
- 9 Number of trichobothria on the external surface of the patella is 17 (5 eb, 2 esb, 2 em, 4 ent, 4 et) Number of trichobothria on the ventral surface of the patella is 9 *Scorpiops* (*Scorpiops*) *farkaci*  
 Number of trichobothria on the external surface of the patella is 19 (Fig. 18) Number of trichobothria on the ventral surface of the patella is 10-13 (Fig. 19) 10
- 10 Number of trichobothria on the ventral surface of the patella is 10-12 (Fig. 19) *Scorpiops* (*Euscorpiops*) *longimanus*  
 Number of trichobothria on the ventral surface of the patella is 13 *Scorpiops* (*Euscorpiops*) *binghami*
- 11 Carinae on patella and manus distinct and granular, anterior or inner surface of patella armed with a strong, tuberculate denticle *Locheles australasiae*  
 - Carinae on patella and manus not very distinct, weakly granular to obsolete, anterior or inner surface of patella armed with few very weakly tuberculate granules *Locheles nigripes*

## List of Scorpionida from Thailand

Buthidae Simon, 1879

*Isometrus* (*Isometrus*) *maculatus* (De Geer, 1778)

? *Isometrus* (*Reddyanus*) *vittatus* Pocock, 1900

*Lychas* *krab* sp. n.

*Lychas* *maculatus* (Fabricius, 1798)

*Lychas* *scutellus* C. L. Koch, 1845

*Thaicharminus malankar* gen. n., sp. n.

Scorpiopidae Kraepelin, 1905

*Scorpiops* (*Scorpiops*) *farkaci* Kováčik, 1993

*Scorpiops* (*Euscorpiops*) *binghami* Pocock, 1893

*Scorpiops* (*Euscorpiops*) *longimanus* Pocock, 1893

Ischnuridae Pocock, 1893

*Locheles australasiae* (Fabricius, 1775)

? *Locheles nigripes* (Pocock, 1897)

Scorpionidae Peters, 1862

*Heterometrus* (*Heterometrus*) *laoticus* Couzou, 1981

*Heterometrus* (*Heterometrus*) *spunifer spunifer* (Hemphill & Ehrenberg, 1828)

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## Mammalian fauna of the Svjatoj Nos peninsula and isthmus, the Baikal Lake, Russia

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### Distribution, mammals, Baikal Lake

**Abstract.** In 1991–1993, 32 species of wild mammals were recorded in the Svjatoj Nos peninsula and isthmus, including *Myotis brandii* and *Myotis ikonnikov*, that are new for the studied area. The list of mammals known from the Svjatoj Nos peninsula and isthmus (43 wild species) is presented. Species identity of *Sorex minutus*, *Sorex caucasicus*, *Sorex tchadon*, *Sorex daphaenodon* and *Sorex araneus* obtained from the studied area was confirmed by karyologic analysis.

### INTRODUCTION

The Zabajkal'skij National Park was founded on Eastern bank of the Baikal Lake, Siberia, in 1989. An important part of NP is area of the Svjatoj Nos peninsula and isthmus. We realised a long-term research work there and received numerous faunal data. There is a lot of interesting faunal data in many publications and especially in unpublished research reports. The aim of present study is a complete review of previous references and our original data.

The first references concerning mammals of the Svjatoj Nos area are those by Doppel'mar (1926), Turov (1924, 1936) and by the staff of the Barguzinskij reserve after its foundation in 1916. Besides of further studies (cf. Lípa & Reiter 1992) the recent reports by Moložnikov (1970, 1974a, 1974b) are worth of a mentioning as a detailed recent source of data on the large and game species. The first list of mammals of the Svjatoj Nos peninsula was presented by Moložnikov (1974a) but as small mammals are concerned, it is to be looked upon as a superficial. The species of probably presented small mammals and large mammals probably migrating through the area were supplemented into the faunal list presented by Švecov & al. (1974), but without a new research work. After a brief study in 1988 a faunal list of mammals of the Zabajkal'skij National Park was presented by Jumov & al. (1989) and Jumov (1990). Faunal lists by Moložnikov (1974a), Švecov & al. (1974), Jumov & al. (1989) and Jumov (1990) are limited to simple enumeration of species without providing sources of the data and/or more details of fauna, statuses of individual species. This concerns also data on localities and methods of recording and identification of small mammals too. There is no way to distinguish from which part of the National Park area the species included in papers by Jumov & al. (1989) and Jumov (1990) were recorded. That is why we can not use most of the records presented by Jumov & al. (1989) and Jumov (1990) in our report. We obtained some more concrete data



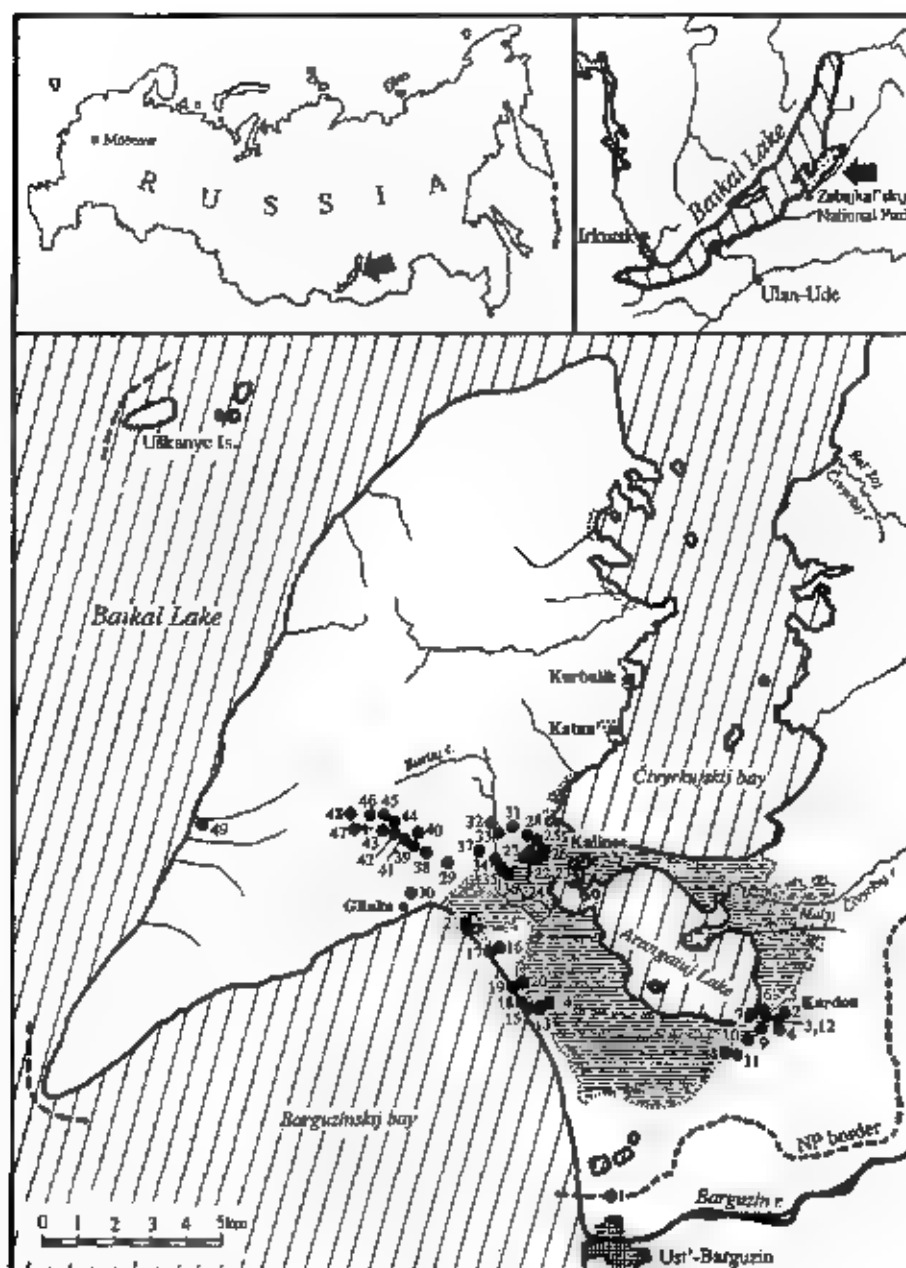


Fig. 1 Map of the Svjatoj Nos peninsula and isthmus with survey of localities where mammals were trapped. For locality descriptions see Appendix.

Additional records obtained from other members of the expedition are marked: FF = Frederic Forget, JM = Jiri Mikovsky, PM = Pavel Muncinger, RP = Richard Peška, PP = Pavel Pešout, PSk = Petr Skřivan, PSI = Pavel Slunečko, DS = David Storch, MŠ = Miroslav Šlek, AT = Aleš Toman.

For complete list of trapping localities see Appendix, geographic relations shows the map in Fig. 1

All the collected mammals were weighted and measured and from selected specimens chromosomal sets were prepared. The mammals were identified after external characters with the help of the keys by Gromov & al. (1963), Krivolev (1984) and Judin (1989). In taxonomically complicated groups additional methods were used. In shrews (genus *Sorex*), keys by Judin (1989) and Sergeev & Haritonova (1987) were used for nonmetric skull identification. Comparisons with the skulls from the Buryat Scientific Centre in Ulan-Ude were also helpful. Finally, karyotypes prepared from selected specimens were used to confirm their identification. The last method was used for *Mus musculus* and *Bats*, especially the complicated group of *Myotis (Sebysius)*, were identified using the key by Kuzjakia (1950), for consultation were used the papers by Hanák (1970), Streškov (1983), resp. Streškov & Buntova (1982). For general taxonomic reference and nomenclature we followed Wilson & Reeder (1993).

For a general geographical description of the Svjatoj Nos isthmus see Mikovsky & al. (1992), a detailed geobotanical description was given by Chytrý & Pešout (1992). Other parts of the Svjatoj nos are described by Imethenov & al. (1990).

Following abbreviations will be used in the text: Svjatoj Nos peninsula = Sv. Nos pen., Svjatoj Nos isthmus = Sv. Nos ist., Zabajkal skj National Park = ZNP

## SYSTEMATICAL SURVEY OF RECORDED MAMMAL SPECIES

### *Sorex araneus* Linnaeus, 1758

Collected at the localities 2a (2 specimens), 2d (1 spec.), 8 (1 spec.), 10a (2 spec.), 10b (6 spec.), 10d (2 spec.), 10f (3 spec.), 10h (1 spec.), 10i (1 spec.), 27 (1 spec.), 3..b (1 spec.), 31f (5 spec.), 32d (1 spec.), 35a (1 spec.), 36b (1 spec.). Common in the wet light taiga, in the forest ecotones and successional stages. Karyotypes of one male and one female from the Sv. Nos ist. and of three males and one female from near west slopes of the Barguzin Mts. Bolšaja Čeremšanaja river, were prepared. Species identity of *Sorex araneus* was confirmed for sure this way. Chromosomal polymorphism was found  $2N = 29-30$ ,  $2Na = 26-28$  (Zima & al. 1994). It is interesting that prior to our investigations, *Sorex araneus* was caught rarely in the area of the Barguzin Mts. and the Sv. Nos pen. (Švecov & al. 1984). There was only one specimen caught recently on the west slopes of the Barguzin Mts. by Švecov & al. (1980) and one specimen on the Sv. Nos pen. (Švecov & al. 1984). The index of dominance (Id) was evaluated in percent as a quotient of the number of specimens *Sorex araneus* from all the specimens of *Sorex* genus. The highest Id = 32.5% on the eastern bank of Baikal Lake was found by Bojčenko (1980) on the northern slopes of the Hamar-Daban Mts. Id was evaluated by Maturova (1982) for a more northern locality, the Ulan-Burgasy Mts. too. The limits were evaluated from 4.5% to 14.5% for different biotopes, 7.9% generally (Maturova 1982). *Sorex araneus* has Id = 9.5% in our material from the Sv. Nos pen. and ist., Id = 21% in our unpublished data from Bolšaja Čeremšanaja river, west slopes of the Barguzin Mts. Towards the east and the north this species was collected rarely and Id was very low (Švecov & al. 1984, Malyšev 1986). Judin (1989) and Švecov & al. (1984) comment it as an effect of the border of the areal.

### *Sorex minutus* Linnaeus, 1766

Collected at the localities 10a (4 spec.), 13d (5 spec.), 14 (1 spec.), 16 (1 spec.), 36b (1 spec.). Most of the localities were wet places on marches edge, in taiga there were collected subadult specimens only. Karyotypes of 2 spec. were prepared  $2N = 42$ , no abnormalities recorded (Zima in litt.). A common species around all the Baikal Lake (Švecov & al. 1984).

***Sorex caecutiens* Luxmann, 1788**

Collected at the localities 2c (3 spec.), 2d (1 spec.), 8 (10 spec.), 9 (3 spec.), 10a (1 spec.), 10b (4 spec.), 10c (1 spec.), 10d (2 spec.), 10f (10 spec.), 10g (2 spec.), 10h (12 spec.), 10i (4 spec.), 11 (6 spec.), 12a (1 spec.), 13d (1 spec.), 16 (1 spec.), 27 (6 spec.), 30 (1 spec.), 31b (10 spec.), 31c (1 spec.), 31e (1 spec.), 31f (2 spec.), 32d (2 spec.), 35a (2 spec.). Recorded in all wooded areas, forest successional stages and ecotones of the studied area. Karyotypes of 3 spec. were prepared, 2N = 42, no abnormalities recorded (Zima in litt.). The most abundant and frequent species of shrews in Sv. Nos pen. and in all the Baikal region (Švecov & al. 1984).

***Sorex isodon* Turov, 1924**

Collected at the localities 2a (1 spec.), 2d (1 spec.), 8 (8 spec.), 9 (4 spec.), 10a (6 spec.), 10f (8 spec.), 10i (1 spec.), 11 (5 spec.), 12d (1 spec.), 29 (1 spec.), 31a (5 spec.), 31b (1 spec.), 31c (1 spec.), 32d (5 spec.), 35a (3 spec.), 35b (3 spec.), 36a (4 spec.), 38 (1 spec.), 40 (1 spec.). Common in the wooded parts of studied area and in subalpine belt. Karyotypes of 4 spec. were prepared, 2N = 42, no abnormalities recorded (Zima in litt.). A widespread species of the Baikal region (Švecov & al. 1984).

***Sorex tundrensis* Merriam, 1900**

Not recorded by us. From the Sv. Nos pen. reported by Moložnikov (1974a) as a common species in the wooded areas. This species was not recorded by Maturova (1982) at the Ulan-Burgasy Mts., by Gaguna & Tugarin (1977) near the Kotokel' Lake, by Ijankin (1977) at the Barguzin valley and by Černikin (1988) at the Barguzin reserve. Švecov & al. (1984) comments this species as practically absent in all the area. That is why we are not convinced that this species is present on the studied area.

***Sorex daphaenodon* Thomas, 1907**

Collected at the localities 10f (1 spec.), 13b (3 spec.), 13d (7 spec.) and 16 (2 spec.) on the edge of marches and near the light taiga. Karyotypes of two males and one female were prepared, 2N in males = 29, in females = 28, 2Na = 26 (Zima in litt.). A frequent but not abundant species in the Baikal basin (Švecov & al. 1984).

***Neomys fodiens* (Pennant, 1771)**

Collected at the localities 20 (1 spec.), 31d (3 spec.), 31f (3 spec.), 35b (3 spec.), 36a (2 spec.) and 36b (1 spec.) on the edge of the marches at Kedrovka (Lipa & Reiter 1992) and on the bank of the Burtuj creek. Directly observed 1 individual foraging in the creek at Kordon, Arangatuj Lake (Goša, national park worker, in verb.). Widespread in the all the Baikal region (Švecov & al. 1984).

***Myotis brandti* (Eversmann, 1845)**

Collected at the localities 4b (1 male and 1 female), 4c (1 male and 3 females), 25b (1 male and 1 female), 32b (1 female), 32e (3 males) and 32g (2 males). In the ZNP territory it has been recorded for the first time (Jurnov 1990). This species is included in the Red Data Book of Buryatia (Pronin 1988). By Švecov & al. (1984) reported as a probably widespread, but not well known species.

***Myotis ikonnikovi* Ognev, 1912**

Collected at the localities 4c (1 male and 1 female), 18c (1 male), 25b (2 males), 32b (1 male and 2 females), 32e (2 males and 1 female) and 32g (2 males and 1 female). In the ZNP

territory it has been recorded for the first time (Jumov 1990). This species is included in the Red Data Book of Buryatia (Pronin 1988). By Švecov & al. (1984) reported as a common species of the north part of the Baikal region.

***Myotis daubentonii* (Kuhl, 1817)**

Collected at the localities 4b (2 males and 2 females), 4c (1 male), 18c (1 male and 3 females) - JM, 23c (3 males and 1 female), 25b (1 male), 32b (2 males and 3 females), 32e (2 males and 2 females), 32f (2 males and 1 female) and 32g (1 male). Breeding colony about 50 individuals recorded in a destroyed wooden building on a small island in the Arangatuj Lake (August 27 1992 DS and PM). Two males mistnetted at Kulinoe on August 20, 1991, 1 male and 1 female mistnetted at Kedrovka on August 22 and 23 1991 and 3 males and 3 females mistnetted at Monahovo on August 27, 1991 by FF. Some of these localities are mentioned by Lipa and Reiter (1992). This species is included in the Red Data Book of Buryatia (Pronin 1988). By Švecov & al. (1984) it is reported as the most frequent species of bats of the Baikal region.

***Eptesicus nilsonii* (Keyserling et Blasius, 1839)**

Collected at the localities 4b (1 female), 4c (1 male and 1 female), 18c (1 female) - JM, 25a (2 males and one specimen with unidentified sex), 32b (5 females), 32f (3 females). One female mistnetted at Kedrovka on August 23, 1991 - FF. Reported by Lipa & Reiter (1992), too. This species is included in the Red Data Book of Buryatia (Pronin 1988). By Švecov & al. (1984) reported as a common species of the Baikal basin.

***Plecotus auritus* (Linnaeus, 1758)**

Collected at the localities 18c (1 male) - JM and 23c (2 males and 1 female). Mistnetted at Monahovo on August 27 and 28, 1991 (2 males) by FF. Mentioned by Lipa and Reiter (1992) from Kulinoe, too. This species is included in the Red Data Book of Buryatia (Pronin 1988). By Švecov & al. (1984) reported as a widespread species of the Baikal region.

***Canis lupus* Linnaeus, 1758**

One couple directly observed on the marches edge on isthmus near the mainland taiga near the Čivirkujskij bay, footprints of the other couple found at the same place - between June 29 and July 1, 1993, MŠ and AT. Voice of two individuals was heard at Kordon on September 21, 1993. 2-5 individuals overcrossed the ZNP area during winter censusing in 1993 (Frolov & al. 1993a). A widespread but decreasing species of the Baikal region (Švecov & al. 1984).

***Vulpes vulpes* (Linnaeus, 1758)**

We observed two juveniles on the road near Kordon (30 June, 1992). One individual observed on the edge of marches of isthmus near the mainland taiga near the Čivirkujskij bay on July 1 1993 - MŠ and AT. A skull found near Kulinoe at the locality 25 on September 8, 1993. Jumov (1990) found den at Kovr.žka. Censusing for the whole ZNP area. 1990 - 22 ind., 1992 - 51 ind., 1993 - 43 ind. (Ovdin & al. 1990a, Frolov & al. 1992a, 1993a). A widespread species of the Baikal basin (Švecov & al. 1984).

***Lynx lynx* (Linnaeus, 1758)**

Footprints of 1 ind. recorded on the halfway on the road Glinka - Burtuj creek bridge on August 31 1992. We think we recorded an accidental migration. 2 ind. recorded during the winter censusing on the whole ZNP area in 1990 (Ovdin & al. 1990a). Overcrossings of 2 ind.



- 4 ind. recorded in 1993 (Frolov & al. 1993a). A common species of the Baikal basin but not frequent in the north (Švecov & al. 1984).

***Lutra lutra* (Linnaeus, 1758)**

One individual directly observed by PSI and RP swimming in Baikal Lake near Golaja Gora on July 18, 1993. 18 ind. always censused on the ZNP territory in 1990 (Ovdin & al. 1990a), 1992 and 1993 (Frolov & al. 1992a, 1993a). This species is included in the Red Data Book of Buryatia (Pronin 1988). A rare species, 150-200 ind. survive in the whole Buryatia (Švecov & al. 1984).

***Martes zibellina* (Linnaeus, 1758)**

Observed near Čivirkujskij bay in forest near the edge of the marches of isthmus near mainland - 1 ex on 30 June 1993, MŠ and AT. Exterminated at Sv Nos pen. area in the past, the first new record was in 1932, about 15-20 ind. in 1974 (Moložnikov 1974b). Ovdin (1991) shows a rapid increase of abundance during 1988-1991 period from 80 ind. to 750 ind. on whole ZNP area. *Martes zibellina* is censused by staff of the ZNP. Totals for the ZNP area: 1990 - 551 ind., 1992 - 525 ind., 1993 - 505 ind. (Ovdin & al. 1990a, Frolov & al. 1992a, 1993a). Present practically in all districts around the Baikal Lake, populations increase in protected areas towards the natural abundance (Švecov & al. 1984).

***Gulo gulo* (Linnaeus, 1758)**

Not recorded by us. Recorded by Moložnikov (1974b) and Švecov & al. (1974) as a rare migrant. Two individuals censused in the whole ZNP in 1990 (Ovdin & al. 1990a). ZNP territory overcrossed by 2 or 3 ind. in 1993 (Frolov & al. 1993a). A rare species but present in the wooded mountain areas of the Baikal basin (Švecov & al. 1984).

***Mustela altaica* Pallas, 1811**

Not recorded by us. One skull found at Kovrižka on 22 July 1991 (Lipa & Reiter 1992.). We don't exclude that it is only an accidental migrant or the skull was transported by a bird of prey or an owl. The nearest locality is reported by Ljamkin (1977) from the Barguzin valley. Lives in the steppe and forest-steppe districts, is present in the many mountain ranges and river valleys but everywhere rare (Švecov 1980).

***Mustela nivalis* Linnaeus, 1766**

Not recorded by us. Reported by Moložnikov (1974a). Occures in the whole Baikal region but very low densities are reported (Švecov & al. 1984).

***Mustela erminea* Linnaeus, 1758**

Not recorded by us. Reported by Moložnikov (1974a) and Švecov & al. (1984). This species is censused by staff of the ZNP. Total numbers for whole the ZNP area: 1992 - 48 ind., 1993 - 46 ind. (Frolov & al. 1992a, 1993a). A widespread species in the Baikal region (Švecov & al. 1984).

***Mustela sibirica* Pallas, 1773**

One male caught by dogs at marches edge near Kordon on June 24, 1992. Censused by staff of the ZNP totals for the whole ZNP area: 1990 - 6 ind. (Ovdin & al. 1990a), 1992 - 64 ind., 1993 - 86 ind. (Frolov & al. 1992a, 1993a). A widespread species in the Baikal region (Švecov & al. 1984).

***Phoca sibirica* Gmelin, 1788**

Frequently found dead on beaches of the Baikal Lake at Kedrovka in 1991 (Lipa & Roster 1992), in summer 1992, 1993 at the same place and on the west shore of the Sv. Nos pen. In July 1993, Ivanov (1938) in Pastuhov (1974) noticed the beaches of Sv. Nos and the Uškan's islands to be the last mating places of *Phoca sibirica*, because it was exterminated in the other parts of Baikal Lake. The Barguzinskij and the Čivirkujskij bays are reported as the meeting places of seals during the winter period (Pastuhov 1974). Since the water level of Baikal Lake rose in 1962 seals are known to frequently visit the Aranganj Lake in the autumn. Several hundred individuals were observed in the autumn 1973 (Pastuhov 1977). About 65 000 individuals live in the Baikal Lake in recent years (Švecov & al. 1984).

***Ursus arctos* Linnaeus, 1758**

We noticed feces, footprints, damaged ant-hill & voice, smell and skeletal remains, or directly observed bears in all parts of the Sv. Nos pen. and ist. Recorded in the alpine and subalpine belts, all types of taiga, in marches, on beaches of Baikal, and around the settled places (Kordon, base camp, Kulinoe). Censused by staff of the ZNP. Results for the Sv. Nos pen., 1991 - 80 ind., 1992 - 70 ind. and 1993 - 54 ind. (Frolov & al. 1991b, 1992b, 1993b). Moložnikov (1974b) found a bear population at the Sv. Nos pen. endangered between 1967 and 1973 (10 ind.). A widespread and abundant species of the Baikal region (Švecov & al. 1984).

***Moschus moschiferus* Linnaeus, 1758**

Not recorded by us. Observed at the Sv. Nos area (Ustinov 1961). The other data are absent. Švecov & al. (1974, 1984) admit rare individual migrations. Occurs dispersally in the wooded parts of the mountains around whole the Baikal Lake.

***Cervus elaphus* Linnaeus, 1758**

Not recorded by us. Turov (1924) in Moložnikov (1970) reports this species as a common. Švecov & al. (1974) consider this species extinct at Sv. Nos and report rare migrations only. Ovdin & al. (1990) report 18 ind. for the whole ZNP in 1990 (Sv. Nos - 0 ind.). Censused 32 ind. in 1992 and 1993 for the whole ZNP territory (Frolov & al. 1992a, 1993a). A common species of the mountain forests (10000 ind. in the Baikal basin) - Švecov & al. (1984).

***Alces alces* (Linnaeus, 1758)**

The young individual was observed on the road Glinka - Kurbulik about 1 km far from Glinka on June 18, 1993 - PSk. Droppings found in taiga 700 m upstream from the bridge across the Burtuj creek in June 1993 - PSk. Adult male was observed at the edge of marches of pathmas near mainland near the Čivirkujskij bay on June 29, 1993 - MŠ and AT.

Footprints of young individual were found on the road 1 km far from Kordon on September 19, 1993. Footprints of several individuals registered around feeding place 3 km north from Kordon in September 1993. Ovdin (1991) reports that the density of Elk's population on the ZNP territory increased from 25 ind. to 40 ind. between 1988-1991. 10 ind. recorded in the Sv. Nos pen. in 1990 (Ovdin & al. 1990a). Totals for whole the ZNP territory are 41 ind. in 1992 and 42 ind. in 1993 (Frolov & al. 1992a, 1993a). A widespread species of the the Baikal region (Švecov & al. 1984).

***Capreolus pygargus* (Pallas, 1771)**

Commonly noticed voice and droppings and directly observed at Kordon (June, August and September 1992, June 1993). Droppings and footprints observed in all the wooded parts of both slopes of the Sv. Nos pen. (July and September 1993). Only 2 ind. recorded during the winter

censusing in 1990 in the Sv. Nos pen. (Ovdiin & al. 1990a).

#### A common species

in the most of the Baikal region (Švecov & al. 1984).

#### *Rangifer tarandus* (Linnaeus, 1758)

Not observed by us. An extinct species in the Sv Nos pen. (Moložnikov 1974b, Švecov & al. 1974). Regularly observed in the Sv Nos pen. in twentieth of this century, but were exterminated by man, the last individual was shot in 1964 (Moložnikov 1974b).

#### *Sciurus vulgaris* Linnaeus, 1758

Several times observed in taiga at the Sv Nos pen. We have never seen this species in a subalpine belt. *Sciurus vulgaris* is censused by staff of the ZNP. Reported from the peninsula and the isthmus in 1990, 1992 and 1993, total numbers of individuals for the whole ZNP area, 1990 - 507 ind., 1992 - 522 ind., 1993 - 414 ind. (Ovdiin & al. 1990a, Frolov & al. 1992a, 1993a). A common species of all wooded areas of the Baikal basin (Švecov & al. 1984).

#### *Tamias sibiricus* (Laxmann, 1769)

Observed in taiga at Kordon and at the Sv. Nos pen. Many times seen in a subalpine belt in the Sv. Nos pen. Common in a light taiga in all parts of the isthmus (Lipa & Reiter 1992), also observed there in 1992, 1993. A widespread species in the whole Baikal region, absent only in steppe parts, open areas and marches (Švecov & al. 1984).

#### *Pteromys volans* (Linnaeus, 1758)

Not recorded by us. From the Sv Nos pen. reported by Moložnikov (1974a). The lack of records may be caused by a hidden way of life. It is considered to be a widespread species of taiga in the whole Baikal region (Švecov & al. 1984).

#### *Sicista betulina* (Pallas, 1779)

Collected at the localities 12a (1 spec.), 35b (1 spec.) and 40 (1 spec.). Accidentally killed on the bottom of a bouldered valley above Makarovo in height about 1,000 m a.s.l. on June 29, 1992 (1 spec.) - PP. Found dead near the base camp at Kedrovka on June 18, 1993 - PSk (1 spec.). Found dead on the road near Kordon on September 18, 1993 (1 spec.). The north-eastern border of the distribution range lies in the western Zabaykal'e region (the region eastwards from the Baikal Lake) (Švecov & al. 1984). The most eastern localities are Verhnaja Angara (Matyšev 1986) and the Barguzin river valley (Ljamkin 1977). This species is absent in the Barguzin reserve (Černukin 1988). A rapid decrease in maximum altitudes recorded for *Sicista betulina* towards the northern margin of its distribution range is worth of interest (Ljamkin & al. 1984): the Altai and Sayan Mts. - 2000 m a.s.l. (Judin & al. 1979 in Ljamkin & al. 1984); the Hamar Daban Mts. - 1800 m a.s.l. (Švecov 1977); the Ulan-Burgasy Mts. - 1200 m a.s.l. (Maturova 1982); the Sv Nos pen. - 1100 m a.s.l. (our observation) and north-east Verhnaja Angara river basin at 600-700 m a.s.l. (Ljamkin & al. 1984).

#### *Clethrionomys rufocanus* (Sundevall, 1846)

Collected at the localities 2a (7 spec.), 2b (5 spec.), 2c (1 spec.), 3 (14 spec.), 4a (3 spec.), 6 (1 spec.), 10a (7 spec.), 10b (13 spec.), 10c (2 spec.), 10f (5 spec.), 10g (13 spec.), 10h (6 spec.), 12a (26 spec.), 12b (1 spec.), 12c (46 spec.), 12d (31 spec.), 12e (21 spec.), 13c (1 spec.).

31a (1 spec.), 31b (9 spec.), 31c (1 spec.), 38 (1 spec.), 43 (3 spec.) and 44 (4 spec.). A common species in taiga, clearings and synanthropic habitats surrounded by taiga. Most frequent in the successional stage after fire of light taiga (loc. 12) and a subalpine belt. Besides of *C. rufocanus* this is the most abundant and frequent ground mammal of the studied area. A widespread species in all wooded biotopes in the Baikal region (Švecov & al. 1984).

***Clethrionomys rutilus* (Pallas, 1779)**

Collected at the localities 2a (4 spec.), 8 (1 spec.), 10a (3 spec.), 10b (5 spec.), 10d (1 spec.), 10f (16 spec.), 10h (25 spec.), 10i (1 spec.), 12a (3 spec.), 12c (4 spec.), 12e (2 spec.), 13a (2 spec.), 13b (4 spec.), 13c (1 spec.), 16 (9 spec.), 17 (14 spec.), 18a (4 spec.), 18b (8 spec.), 19a (3 spec.), 19b (4 spec.), 20 (2 spec.), 23a (1 spec.), 27 (3 spec.), 29 (3 spec.), 31a (6 spec.), 31b (19 spec.), 31d (5 spec.), 31e (10 spec.), 31f (31 spec.), 35b (2 spec.), 39 (15 spec.), 40 (8 spec.), 45b (1 spec.), 46 (2 spec.), 47a (1 spec.), 48 (1 spec.) and 49 (1 spec.). The most frequent mammalian species of the studied area. A common species in taiga, clearings and successional stages after fire of taiga. Frequently collected in a subalpine belt, sandy dunes on the edge of marches and settled places near forest. Also occurs in the top parts of the peninsula in an alpine belt. Seems to be more frequent in unwooded habitats than *C. rufocanus*. A widespread species in the Baikal region (Švecov & al. 1984).

***Ondatra zibethicus* (Linnaeus, 1766)**

Droppings observed at whole Kedrovka and in marches of the isthmus. Introduced to the Sv. Nos wetlands in 1936 (Moložnikov 1974b). Abundant species in marches, regularly censused by staff of the ZNP: 1990 - 7000 ind., 1991 - 4370 ind., 1992 - 5100 ind., 1993 - 5460 ind. (Ovdiin & al. 1990b, Frolov & al. 1991b, 1992c, 1993c). In recent years approximately 2000 ind. are culled by hunters in the Sv. Nos wetlands (V. S. Mel'nikov and A. K. Beketov in verb.). A frequent species in all suitable places of the Baikal region (Švecov & al. 1984).

***Microtus oeconomus* (Pallas, 1776)**

Collected by us in a shore vegetation of the creek Burtuj, Arangatuj Lake and in the edges of marches at the localities 7 (1 spec.), 8 (1 spec.), 10a (1 spec.), 12c (1 spec.), 13a (3 spec.), 13c (14 spec.), 13d (10 spec.), 14 (1 spec.), 18a (2 spec.), 20 (1 spec.), 26 (5 spec.), 35b (1 spec.) and 36b (2 spec.). In the Baikal region recorded in wet habitats along rivers and creeks and in the marches of forest-steppe and forest zones and a subalpine belt (Švecov & al. 1984).

***Microtus gregalis* (Pallas, 1779)**

Not recorded by us. 3 spec. were collected at Kulinoe in 1988 (B. O. Jumov et L. N. Kalina in verb., Jumov 1990). This is the first record of the species in the region. The nearest previously known locality of *M. gregalis* was 200 km to the south of the Sv. Nos near Zyrjansk (Švecov & al. 1984). The record from Kulinoe is to be looked upon as doubtful because authors did not state an exact place of catching, and they themselves say that it is possible the voles were brought Kulinoe with a big transport of hay (B. O. Jumov et L. N. Kalina in verb.). *M. gregalis* has never been collected at Kulinoe any more (localities 22, 23a, 23b and 26). Typical burrows were not recorded too. A large distance from other localities was noticed before.

***Apodemus peninsulae* (Thomas, 1907)**

Commonly collected by us in many biotopes: light taiga: loc. 10a (1 spec.), 10c (2 spec.), 10e (3 spec.), 10f (15 spec.), 10h (5 spec.), 10i (1 spec.), 17 (9 spec.), 31b (3 spec.), 31e (1

spec.) sand dunes at Kedrovka - loc. 18b (14 spec.), a subalpine belt - loc. 40 (3 spec.), 42a (2 spec.), 44 (2 spec.), 45a (1 spec.), successional stages and ecotones of light taiga - loc. 12c (1 spec.), 12e (3 spec.), 38 (2 spec.), settled places - loc. 19a (9 spec.), 23b (1 spec.). A frequent species of the whole Baikal region (Švecov & al. 1984).

*Mus cf. musculus* Linnaeus, 1758

Not recorded by us in 1992 and 1993. One subadult female collected at the entrance of the ZNP on July 13, 1991 - loc. 1 (Lipa & Reiter 1992). The chromosomal analysis on this specimen was also undertaken, revealing  $2N = 40$ , no abnormalities being recorded; thus, this individual belonged most probably to *Mus musculus* s. str. (Zima in litt.). *M. musculus* been reported by Jumov (1990) from all settled points on the ZNP area. In recent years, it is a common species of all settled places of the Baikal basin including its on the islands (Švecov & al. 1984).

*Rattus norvegicus* (Berkenhout, 1769)

Collected at the locality 15 - the base camp at Kedrovka (17 spec.). One adult couple with fifteen youngs. Observed in the log hut at Kulinoe (1 spec.) - RS in August 1993, droppings were noticed at the same place in July 1992. Also reported from all settled points of the ZNP territory (Jumov 1990 - local people, in verb.). A common species in most of settled points of the Baikal region (Švecov & al. 1984).

*Ochotona hyperborea* (Pallas, 1811)

Collected at the locality 41 (2 spec.). Observed in all vertical zones where are suitable scree slopes (bouldered patches in taiga 100 m above level of Lake Baikal: c. about 550 m a.s.l. to ones on the top of the peninsula: c. 1877 m a.s.l.). A common species in all habitats around the Baikal Lake where are scree slopes present (Švecov & al. 1984).

*Lepus timidus* Linnaeus, 1758

Droppings frequently recorded in taiga, subalpine and alpine belts. The skeletal remains of 2 spec. were found at the locality 31. One individual directly observed on the road between the Burtu creek and Kulinoe in August 1992 (E. D. Ovdin in verb.). *Lepus timidus* is censused by ZNP workers. Reported from the Sv. Nos pen. and isth. in years 1990, 1992, 1993, totals for the whole ZNP are: 1990 - 234 spec., 1992 - 890 spec. and 1993 - 1130 spec. (Ovdin & al. 1990a, Frolov & al. 1992a, 1993a). A widespread species of the Baikal region (Švecov & al. 1984).

## DISCUSSION

The present list of mammal species registered in the Sv. Nos isthmus and peninsula includes 43 wild species. Our own observations include 32 of them. Previous authors reported 31 species for the Sv. Nos pen. (Moložnikov 1974a), 34 species for the Svjatoj Nos peninsula (Švecov & al. 1974) and 26 species for the Svjatoj Nos isthmus (Lipa & Reiter 1992). For comparison see Table 1.

In bats, two species new for the Zabajkal'skij National Park area were recorded - *Myotis brandtii* and *Myotis ikonnikovii* (Jumov 1990).

We did not record three species of rare migrants (*Moschus moschiferus*, *Cervus elaphus*, *Gulo gulo*). As for *Mustela nivalis*, *Mustela erminea* and *Pteromys volans*, we didn't hunt them purposefully (trailing, trapping, etc.), important part or whole their activity is nocturnal.

Tab. 1. Comparison of lists of mammals recorded in the Svjatoj Nos peninsula and isthmus. Legend: + confirmed regular occurrence, (+) recorded migrant individuals, recorded isolated skeletal remains or isolated individuals of species unknown from near territories, not recorded 1-4 previous surveys of records [Moložnikov (1974a)] 2 Švecov & al. (1974); 3 B. O. Jumov and L. N. Kalinina unpublished table of recorded species in 1988. Small mammals were collected in snap traps and pitfall traps; 4 - Lipa & Reiter (1992); 5 - our observations without those reported by Lipa & Reiter (1992).

species	1	2	3	4	5	species	2	3	4	5
<i>Sorex araneus</i>	-	+	+	+	+	<i>Lynx lynx</i>	(+)			(+)
<i>Sorex caecutiens</i>	+	+	+	+	+	<i>Phoca nigricea</i>	+	+	+	+
<i>Sorex isodon</i>	+	+	+	+	+	<i>Moschus moschiferus</i>	-	(+)	-	-
<i>Sorex araneus</i>	+	+	+	+	+	<i>Cervus elaphus</i>	-	(+)	-	-
<i>Sorex tundrensis</i>	+	+	-	+	-	<i>Capreolus pygargus</i>	+	(+)	-	+
<i>Sorex daphnendani</i>	+	+	+	+	+	<i>Alces alces</i>	+	+	-	+
<i>Meromys fischeri</i>	+	+	-	+	+	<i>Rangifer tarandus</i>	(+)	(+)	-	-
<i>Myomys brandti</i>			-	-	+	<i>Peromyscus voles</i>	+	+	-	-
<i>Adymus krasnikovi</i>			-	-	+	<i>Sciurus vulgaris</i>	+	+	+	+
<i>Myomys dambudani</i>	+	+	-	+	+	<i>Tamias sibiricus</i>	+	+	+	+
<i>Eptesicus nelsoni</i>				+	+	<i>Sicista betulina</i>			+	-
<i>Plecotus auritus</i>	+	+		+	+	<i>Clethrionomys rufocanus</i>	+	+	+	+
<i>Canis lupus</i>		-			+	<i>Clethrionomys rutilus</i>	+	+	+	+
<i>Vulpes vulpes</i>	+	+	+	+	+	<i>Onatra zibethicus</i>	+	+	+	+
<i>Ursus arctos</i>	+	+	-	+	+	<i>Microtus oeconomus</i>	+	+	+	+
<i>Martes zibellina</i>	+	+	-	-	(+)	<i>Microtus gregalis</i>	-	-	(+)	-
<i>Gulo gulo</i>	-	(+)				<i>Apodemus peninsulae</i>	+	+	+	+
<i>Mustela altaica</i>	-	-		(+)		<i>Mus cf. musculus</i>	+	(+)	+	
<i>Mustela nivalis</i>	+	+				<i>Rattus norvegicus</i>	+	+	+	-
<i>Mustela erminea</i>	+	+	-	-	-	<i>Lepus timidus</i>	+	+	+	+
<i>Mustela sibirica</i>	+		-		(+)	<i>Ochotona hyperborea</i>	+	+	+	+
<i>Lutra lutra</i>	+	+	-	-	(+)					

so a possibility to meet them in taiga accidentally is a very low. On the contrary, it is very easy to the record these animals on the snow but we didn't work here during a snow period.

There are three potential candidates for an accidental meeting in the studied area. *Mustela erminea* Lesson, 1827, lives in the Barguzin valley (Ljankin 1977, Švecov & Polovinkina 1982). *Meles meles* (Linnaeus, 1758), is recorded from this area too (Švecov & al. 1984). *Sus scrofa* Linnaeus, 1758, four individuals recorded in the Malyj Čivirkuj valley (Barguzin Mts) on the Zabajka'skyj National Park territory in the winter 1993 (Frolov & al. 1993).

The major problem in study of small ground mammals is a low number of localities we investigated in the western slope of the Svjatoj Nos peninsula, that is due to inaccessibility of that region and related technical constraints. The coast of the Svjatoj Nos peninsula with mainland was established during the Quaternary period by a sandy isthmus only (Ljankin 1968). In agreement with Forman & Gordon (1986) we presuppose that diversity of the ground vertebrates decreases from the mainland to the distal parts of peninsula. That is why we are convinced that in the eastern slope it is possible to record most of ground mammalian species living in the peninsula and that some species living on mainland need not occur in the peninsula.

at all. We guess it may concern some species of shrews and rodents: *Sorex ruberatus* Hollister, 1939, *Sorex minutissimus* Zimmerman, 1780, *Alticola macrotis* (Radde, 1862), and *Myopus schisticolor* (Lilljeborg, 1844)] that until now have not been recorded in the studied area. As concerns *S. minutissimus* and *M. schisticolor*, very low densities of their populations and a complicated trapability are to be taken in account (Maturnova 1982, Švecov & al. 1984).

Several species living in the Barguzin valley were not recorded in the Svjatoj Nos peninsula and isthmus, sensu Ljankin (1977): *Spermophilus undulatus* (Pallas, 1778), *Cricetulus barabensis* (Pallas, 1773), *Microtus fortis* Buchner, 1889, *Microtus mongolicus* (Radde, 1861) and *Microtus minutus* (Pallas, 1771). Out of them, *M. minutus* seems to be the hottest candidate for entering the study area – anyhow, until now, in suitable habitats we did not succeed in record either a specimen or a nest (Moložnikov 1974, Švecov & al. 1974, Jumov 1990, Lipa & Reiter 1992, our observations). For the other species there are no suitable conditions in this area (Švecov & al. 1984, Lipa & Reiter 1992).

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Nos pen Mts, 300 m NE of the Glinka cross, ecotone of light taiga and wetland, Jul 5-7, 1992 90 S 1, 2 31 E foot of the Sv Nos pen Mts, Burtuj creek, 100 m-350 m of the bridge in the direction to Monahovo, W of road, light taiga, a) Jul 1-6, 1992 242 S q, 5 b) Aug 27 - Sep 1, 1992 242 S q, 5 c) Aug 26-31, 1992 6 P, 5 d) Aug 28-31, 1992 50 S 1, 1 e) Jun 28 - Jul 3, 1993 242 S q, 5 f) Sep 9-14, 1993 242 S q, 5 32 E foot of the Sv Nos pen Mts, the Burtuj creek bridge, shore surrounding vegetation in closed taiga, a, Jun 29 - Jul 4, 1992 20 L 1, 5 b) Jul 1-6, 1992 2 N, 4 c) Jul 2-6, 1992 8 P 1, 4 d) Aug 27-31, 1992 1 P 1, 4 e) Aug 27-29, 1992 2 N, 2 f) Jun 30 - Jul 3, 1993 1 N, 2 g) Sep 10-11, 1993 3 N, 1 33 E foot of the Sv Nos pen Mts, the Burtuj creek bridge, the place for parking, a synanthropic habitat, Jul 4-7, 1992 0 I d, 2 34 E foot of the Sv Nos pen Mts, Burtuj creek, 800 m downstream from the bridge, humid birch forest, Jun 29 - Jul 1, 1993 100 S, 2 35 E foot of the Sv Nos pen Mts, Burtuj creek, about 1 km downstream from the bridge, wet birch forest with high grass undergrowth, a) Aug 3 - Sep 3, 1992 9 P, 3 b) Aug 3 - Sep 3, 1992 50 S, 3 36 E foot of the Sv Nos pen Mts, Burtuj creek, about 1300 m downstream from the bridge, peatbog with cranberries, a) Aug 31 - Sep 3, 1992 9 P 1, 3 b) Aug 31 - Sep 3, 1992 50 S, 3 37 E foot of the Sv Nos pen Mts, Burtuj creek, 500 m S of the bridge, leafy forest, Jul 1-4, 1992 50 S, 3 38 E slopes of the Sv Nos pen Mts, the first valley N of Glinka, compressed valley of the creek, varied vegetation of humid habitats, Jul 11-12, 1992 50 S 1, 1 39 E slopes of the Sv Nos pen Mts, the first valley N of Glinka, the bottom of the valley on upper limit of forest about 1000 m a.s.l., varied plant community with the elements of shore forest and subalpine vegetation, Jul 9-12, 1992 50 S 1, 3 40 E slopes of the Sv Nos pen Mts, the first valley N of Glinka, S oriented avalanche slope about 1000m a.s.l., varied herb community, Jul 9-12, 1992 50 S 1, 3 41 E slopes of the Sv Nos pen Mts, the first valley N of Glinka, scree slope on the upper limit of forest about 1000 m a.s.l., boulders without vegetation, Jul 9-12, 1992 10 B 1, 3 42 E slopes of the Sv Nos pen Mts, the first valley N of Glinka, the bottom of the valley with boulders about 1100 m a.s.l., herb growth with dominant grasses, a) Jul 1-12, 1992 35 S 1, 1 b) Sep 4-6, 1993 30 S 1, 2 43 E slopes of the Sv Nos pen Mts, the first valley N of Glinka, N oriented fine-grained scree slope about 1300 m a.s.l., varied herb growth with the edge of prostrate pine scrub, Jul 1-12, 1992 15 S, 1 44 E slopes of the Sv Nos pen Mts, the first valley N of Glinka, the bottom of the valley covered with boulders about 1300 m a.s.l., varied alpine meadow community, Jul 9-12, 1992 50 S 1, 3 45 E slopes of the Sv Nos pen Mts, the first valley N of Glinka, the bottom of the valley covered with boulders about 1400 m a.s.l., low herb vegetation, a, Jul 3-4, 1992 10 S d, 1 b) Sep 5-6, 1993 25 S, 1 46 E slopes of the Sv Nos pen Mts, the first valley N of Glinka, the avalanche slope about 1700 m a.s.l. with varied herb and low bush growth, Sep 4-6, 1993 22 S L, 2 47 The Sv Nos pen Mts, the top plateau about 1850 m a.s.l., 300 m W of the highest point of peninsula, humid mountain tundra, a) Sep 4-11, 1993 90 S 1, 2 b) Sep 4-11, 1993 20 P 1, 2 48 The Sv Nos pen Mts, the top plateau about 1850 m a.s.l. 500 m NW of the highest point of peninsula, dry mountain tundra, Sep 4-11, 1993 25 S 1, 2 49 W coast of the Sv Nos pen, estuary of the creek, high humid arch taiga with rich moss undergrowth, Jul 8-11, 1993 300 S 1, 3

## Ecological preferences of epigeic spiders (Araneida) in the systems of many biotopes

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### Spiders, plant association, ecological optimum, statistical tests

**Abstract.** Ecological preferences of epigeic spiders were studied in 27 biotopes with 25 natural xerothermophilous to hygropsychrophilous biocoenoses, a semiartificial young alder growth and a disturbed ruderal site in the Křivoklátsko Biosphere Reserve and its near surroundings (347 pitfall traps filled with formalin solution, each exposed for an average of nine months in 126 stations, in total 126 samples have been evaluated; 378 spider species determined; 35 234 adult specimens collected). 74 spider species were caught in significantly larger numbers in a single biotope with natural biocoenosis, and 52 species in two up to eight ones according to the results of homogeneity tests for the differences in abundance among the biotopes. The biotope which can be considered optimal for each of the 378 species also by means of other tests and computations, accords with the postulate stated by the synthesis of other authors' statements in about 46.0 % of the species; accord at a lower level has been established in 46.6 % of the species, and discord in mere 2.9 %. The comparability of stations was not impaired either by differences in the mechanical permeability of the substrate surface or by differences in the penetration of spiders.

### INTRODUCTION

Spiders are important component of nature from the synecological point of view. Nevertheless, we do not know enough about the ecology of many spiders, particularly about their relations to principal environmental factors and the qualities of ecosystems and biotopes preferred by them and thus indicating their ecological niches. The object of this study has been to provide new details on the ecological preferences of the epigeic spiders by comparing their abundances at different localities in a landscape with many biotopes and natural biocoenoses on the basis of pitfall sampling.

### MATERIAL AND METHODS

#### Study area and sampling sites

The study was carried out within the framework of arachnological investigations made by the first of the present authors in the Křivoklátsko Biosphere Reserve (about 630 km<sup>2</sup>, hereafter KBR) by the river Berounka in Central Bohemia and its near surroundings. The area is characterized by a variety of well-preserved biocoenoses due to the biobistory of farming, dynamic relief of the landscape, relief amplitude (223-616 m a.s.l.) and local climate which is rather influenced by the rain shadow; the daily mean air temperature is about 8.5 °C and annual total precipitation 550 mm. The geological substrate consists mostly of Algonquian shales, Cambrian volcanic acid rocks (above all, palaeoandesite, palaeorhyolite, dacite); gray Carboniferous strata; there are also some basic substrates (diabase, granite). The soil is rather stony. Over 60 % of the area is covered by woodland. There are various xerothermophilous to hygropsychrophilous and submontane biocoenoses with deciduous as well as coniferous woods, remnants of fir woods.

including. Nowadays there are also many artificial spruce growths, there were, however, only isolated and scarce spruce trees before artificial changes took place. KBR includes 18 State Nature Reserves at the present time.

The basic units studied were stations defined and classified as the actual biotopes given below. The number and distribution of the stations were planned according to phytocoenological maps and typological maps of the woods (deposited e.g. at the Board of KBR), literature (Moravec et al. 1982, Neubauer & Neubauerová-Nowotná 1967-1977 and others), consultations with botanists and our own research in such a way that they would cover the range of natural biocoenoses in the study area as fully as possible. Each station was subjectively evaluated during the field work by an empirical marking system.

In total, 126 stations belonging to 27 biotopes were selected, 25 biotopes of the whole set have to be designed as natural.

The description of most of the natural biotopes covered by trees is chiefly based on the identification of a respective plant association and, in some cases, even lower coenotaxa and forest types. The studied rock steppes, often consisting of mosaics of minor plant associations, were summarized according to mobility of many epigeic spiders as belonging to only one biotope; their description is completed by dominant plant associations and plant species. The overall character of herb and moss strata, localization and soil type were respected in the classification of spruce growths and meadows, botanical reconstruction in the case of spruce growths (i.e., topographical identification with former fir woods) was applied in the classification too. Two biotopes, strongly influenced and disturbed by anthropic activities, an amelioration site and a dump, were included for comparison.

In the list of sampling sites given below there are concise descriptions of each of the biotopes studied (bold letters on the left margin) and some stations differentiated by some special quality (bold characters in parentheses); also the number of stations (st.), traps, specimens, and species (spp.) of each biotope is indicated.

#### Open dry and easily drying biotopes with thermophilous plants

**RS** Rock xerothermophilous steppes, 60-80 % of the substrate is overgrown by low vegetation, particularly *Alyssa Potentillietum* and *Jasiono-Festucetum* (da with *Dictamnus albus*, di small hills of diabase tuff in open landscape; pe with numerous shrubs of *Prunus spinosa*; s) the best developed and largest rock steppe c. 3 ha in area, substrate mostly on basic veins and eluvia, discontinuously overgrown by *Stipa joannis*, all on the lower half of a spike rock, with *Geranium sanguineum*, st. on the top of a spilitic rock), 9 st., 26 traps, 3 139 specimens, 180 spp.

#### Light, rocky biotopes with sparse herbs and pines

**DP** *Dicrano-Pinion* alliance "relic rock pine woods": extremely warm and dry stations on the tops of prominent rocks and ridges with isolated dwarf pines, sparse *Chamaebuxus alpestris* and/or other herbs, a thin layer of foamy sand substrate, 3 st., 5 traps, 438 specimens, 49 spp.

#### Oligotrophic pine woods and stands of *Quercus-Pinetum* and *Pino-Quercetum* biotopes

**QP** *Quercus-Pinetum*, at least 80 % of the tree stratum are tall pines with some oaks and birches, there is plenty of *Calluna vulgaris*, *Vaccinium myrtillus*, *V. vitis-idaea* (cvs on siliceous rock, *C. vulgaris* dominant, cvs on sand, *C. vulgaris* and *V. vitis-idaea* abundant, nu nudum type on loamy sand soil, vni with dominant *V. myrtillus* and patches of moss on a rather deep layer of sandy loam substrate); 6 st., 22 traps, 2 724 specimens, 145 spp.

#### Thermophilous and xerophilous dwarf oak woods

**VQ** *Viscaria-Quercetum*, thermophilous oak woods on prominent rocks and hilltops, hard rock substrate, n over 60 % of the area, moss overgrowing up to 40 % of the area, herbs (*Viscaria vulgaris* and others) sparse, scattered stones (ss with quick slate slabs), 6 st., 19 traps, 1 608 specimens, 117 spp.

**OQx** *Cynancha-Quercetum cynicum*, xerophilous, warm and dry oak woods on scree, well exposed to sunshine, with very sparse herbs, mostly *Cynanchum vincetoxicum*, 2 st., 4 traps, 93 specimens, 25 spp.

#### Easily alternately drying oak woods on steep slopes with fine gravel

**COq** *Cynancha-Quercetum portosum* (in Neubauer & Neubauerová-Nowotná 1977), rather high oak wood in the lower half of a slope, sparse *Poa nemoralis*, *C. vincetoxicum* and others, a biocoenosis resembling a poor drying hornbeam-oak wood, 1 st., 2 traps, 343 specimens, 40 spp.

#### Well-developed oak woods on plateaux and gentle slopes

LQ *Luzula Quercetum*, acidophilous, near hilltops, herbs and *Luzula nemorosa* sparse, patches of moss, 3 st., 6 traps, 736 specimens, 58 spp

PQ *Portentula-Quercetum*, alternatively drying, on a slightly rugged plateau, about 35 % of the surface area covered by herbs *Portentula alba* including, a continuous layer of leaf litter, 2 st., 5 traps, 594 specimens, 38 spp

#### Open biotopes of rock debris on slopes

FS Fields of scree with minor lichens on some of the stones (ms in places of medium climatic conditions, ps on cool slopes, there are also deep fissures where lichens can be found even in the summer, *Saxifraga decipiens* in places along the edges, sh well exposed to sunshine, surrounded by dwarf oak woods), 6 st., 23 traps, 1 775 specimens, 113 spp

IAC Initial stages of cool scree woods - fields of scree with numerous ferns and mosses, isolated shrubs (*Ribes*, *Rutus*) and single trees, 3 st., 15 traps, 845 specimens, 68 spp

#### Scree woods with *Acer*, stones and/or gravel, rich humus

ACQ *Acer-Carpinetum*, rather warm scree wood types especially on south-facing slopes. *Poa nemoralis* abundant there are no ferns or hygrophilous herbs, gravel is abundant, covering up to 40 % of the area (ss with quick silt slabs), 6 st., 17 traps, 1 094 specimens, 100 spp

ACp *Acer-Carpinetum argemoneletum*, typical cool and damp talus slope woods, *Taxus baccata*, *Cornus alba* present, herbs overgrowing up to 80 % of the area (tb facies *T. baccata* yew needles on 90 % of the soil surface), 7 st., 17 traps, 1 059 specimens, 75 spp

LA *Lumina-Acernetum lunarietum*, cool scree woods on continuous quick gravel, over 70 % of the area overgrown by *Lumina rediviva* (ss only *T. baccata* and *Abies alba* around the pitfall traps), 2 st., 9 traps, 274 specimens, 34 spp

#### Hornbeam-oak woods

MC *Melampyri-Carpinetum*, lush mesophilous woods on plateaux and gentle and not very steep slopes, herbs common, rather continuous, rich humus (for fresh facies with *Fraxinus excelsior* and *Mercurialis perennis*, running down the gradient of the slope, ps type with abundant *Poa nemoralis*, ps with *Primula veris*), 10 st., 20 traps, 2 538 specimens, 14 spp

#### Beech woods

LF *Luzula Fagetum*, acidophilous with scattered *L. nemorosa*, *Calamagrostis arundinacea*, patches of *V. myrtillet*, 90 % of the ground covered by leaf litter, 6 st., 18 traps, 1 659 specimens, 89 spp

TEI *Tilia cordatae-Fagetum*, lush, rich, submontane, loamy types, mostly on plateaux and gentle slopes, up to 70 % surface covered by *Asperula odorata* (hu humid, in a flat basin), 4 st., 11 traps, 1 490 specimens, 57 spp

TEs *Tilia cordatae-Fagetum*, lush, rich, submontane, stone and gravel types on slope knolls and slopes with many herbs, *Dentaria enneaphyllus* and bracken in particular, 9 st., 22 traps, 1 859 specimens, 66 spp

BS Banks of deep-cut streams in narrow valleys in above mentioned beech woods without continuous floodplain vegetation, only isolated alder-trees at most present (ps with many *Picea excelsa* trees), 6 st., 21 traps, 1 458 specimens, 87 spp

#### Spruce woods and stands

SG Spruce growths in flat basins and on plateaux originally overgrown mostly by moist *Equiseto-Abietetum*, on heavy soils with *Carex pilosa*, grasses, patches of moss including solitary tufts of *Sphagnum* (existence of isolated spruce trees before artificial changes can be supposed in three of the stations situated in basins around spring-edges according to geobotanical research), 5 st., 16 traps, 985 specimens, 88 spp

#### Alder woods

SA *Stellario-Alnetum*, submontane brook alder woods with *Stellaria holostea*, up to 70 % of the area overgrown by herbs, *Luzula rediivna* occurring less, stones frequent, lg interpenetrated by beeches, mb the most boggy stand; 1 st., 26 traps, 1 901 specimens, 94 spp.

CA *Caricet elongatae-Alnetum* in a marshy, clayey terrain near a source area in a wood, with tall sedge, *Carex paniculata*, *Sphagnum* (ex *Carex* predominant, sphagnum moss rare: sph interior parts without track, sphagnum moss covering several area, traps in sphagnum moss); 2 st., 1 traps, 1 235 specimens, 59 spp.

Ag "Alnetum glutinosae", the zone of *Caricet-Alnetum* at the edge of a pool sized approx. 30 x 40 m, alder trees with prop roots, *Juncus*, tufts of *C. paniculata*, patches of *Sphagnum*, marshy soil; 1 st., 3 traps, 417 specimens, 35 spp.

MA "Molinia arundinacea - *Alnus glutinosa*", partly planted, sparse young alder stand, trees 2-3 m in height, 0.5 m high tufts of *M. arundinacea* in a broad amelioration plain; 1 st., 2 traps, 487 specimens, 53 spp.

#### Semishaded river floodplain with shrubs

St *Salicetum triandrum*, scattered willow shrubs, tall grasses, *Urtica dioica*, sand and stones, debris; 3 st., 7 traps, 009 specimens, 59 spp.

#### Reed stands

Ph *Phragmitetum* in the inundation open area of a brook, reed belt at least 5 m wide, traps in its middle; 1 st., 5 traps, 334 specimens, 48 spp.

#### Grass biotopes in fresh to wet open areas

Mh Meadows, fresh humid, grass on 90- 00 % of the surface, with *Polygonum bistorta*, *Filipendula ulmaria*, scarce *Juncus* (be a broad balk in a field enclave in woods, be a balk in an open farmland: fu with dominant *P. ulmaria*, not regularly mowed, encircled by woodland), 3 st., 19 traps, 4 607 specimens, 118 spp.

#### Disturbed anthropogenic dump and landfill biotopes

Ru A place that had been used for tipping fifty years at least, with ruderals, *Urtica*, *Atriplex*, bricks, metal plates, boards, pools of dung water, near a field, situated 250 m from the village; 1 st., 3 traps, 553 specimens, 69 spp.

#### Sampling methods

Spiders were captured in pitfall traps 500 cm jars (diameter 9 cm, height 15 cm) buried flush with the ground and filled up to one third with a 4 % formalin solution. In November and December, kitchen salt (two tablespoons) was added and rooflets (chip-wood board 30 x 30 cm) were fixed c. 10 cm above the pitfalls.

A total of 347 traps was used. The traps were placed in the centre of each station (bank stations excluding), mostly in pairs. A single pitfall was used in some small stations; in some long and heterogeneous bank biotopes, as many as seven pitfalls per station were placed alongside the streams. The traps were spaced at least 10 m apart. In woods they were placed at least 1 m away from trees, at banks of brooks or rills at a distance of c. 50 cm from the border of the water stream in its average level and, at the edge of a large pool in the alder wood, in sedge tufts at a distance up to 1 m from the continuous water surface. Each trap was exposed for an average of nine months, from 15 March to 15 December of one of the years during the period 1979-1983. Samples were removed and the preserving liquid was changed in winter also with the help of a small suction pump approx. every month, exceptionally at two-week intervals. The whole material of adult spiders sampled in each of the stations by means of all traps in every station, i.e. in mostly pooled samples, called only "samples" hereafter, was evaluated. In total, 126 samples have been thus evaluated.

#### Material

In total 35 234 adult spiders of 378 determined species and about 5 000 juvenile and subadult individuals were caught in the pitfall traps. Only c. 45 specimens of five species, including one sample with *Pardosa monticola* (L.) and perhaps *P. agricola* (Thorel) could not be determined down to the species level.

The first of the authors is responsible for the determination. A part of the material had already been used in studies of the archaological differentiation of communities (Šmaha 1983a, b, 1985; Šmaha & Páňžka 1989).

### Mathematical methods

Differences in the occurrence of individual species in individual stations and biotopes (material of a species from all stations of a biotope representing a biotope), regardless of the occurrence of other species, were studied at first, whilst as the most important results are considered the values and  $\chi^2$  tests of relative abundance of individual species in biotopes relative to the number of traps laid  $a_i$  test. The application of the quantal distribution  $\chi^2_{a_i}$  with probability  $\alpha = 0.05$  for analysis of abundance differentiation of each species of which at least 15 specimens were trapped has been confirmed by the "Monte Carlo" permutation method. the quantils for each of species, of which less than 15 specimens were trapped, have been thus computed implicitly (see Appendix 1 for further details).

Also, we tested the differences in the relative abundances of species in individual stations and differences in the relative number of stations where a species has been found (their frequency), and some other tests as well as computation of average numbers of specimens of each species per trap were performed in order to verify the indication of the biotope(s) most frequented by a given species. In many cases, this was done to determine the most preferred optimum biotope as well.

Apart from that, we studied the relative differences in the numbers of specimens of each spider species caught in each biotope in relation to the total number of spiders there trapped i.e. percentage incidence. Also, we studied the relative differences between the number of trapped specimens of a species and the number of specimens of species similar in size and life habits and thus also mobility in this way, higher functional relevancy and precision of results were expected. Only spiders of families frequently trapped in the pitfalls were used for this analysis. These families were classified into two ecomorphological groups: A - gramer (cephalothorax mostly > 2 mm - cursorial or periodically vagrant spiders of ten families, viz., Atrypidae, Segneriidae, Dyadenidae, Eresidae, Lycosidae, Agelenidae, Cyathidae, Amaurobiidae, Triaenocidae and Gnaphosidae (89 species in the material); B - mostly smaller (cephalothorax < 2 mm) and relatively less mobile spiders of families Pholidae and Linyphiidae (166 species in the material) (for  $\%_A$ ,  $\%_B$  see Appendix 1). Species unfit to be classified to either of those two groups (123 species) represent 32.5 % of the total numbers of specimens.

The entire material was also subjected to canonical correspondence analysis based on abundance variability of all species in individual stations (CCA, four axes,  $\alpha=0.05$ , ecological programme CANOCO, Ter Braak 1987).

### RESULTS

Analyses of the abundance of spiders found in at least two biotopes by means of test of homogeneity ( $a_i$ ) show that 227 species, i.e. 60.1 % of the 378 species determined, were caught in a significantly larger numbers in one (75 species) or more (152 species) natural biotopes. The results of this testing and many statements of other authors, often consistent with these findings, may suggest that various spider species show equal preference to two or more biotopes (e.g., *Celotus inermis*, *Pardosa lugubris*, *Trochisa terricola*, *Diplocephalus latifrons*, *Salixia diuersa*). Nevertheless, even in these cases we cannot exclude a gradation of the intensity of preference. Different other computations also indicate in a majority of these species as well as in a majority of other species without any significant result of this test, that only one biotope is most frequented by a given species.

The processing based on the ecomorphological groups has been very helpful for the determination of the biotope with the highest occurrence of a particular spider. The trends of sequence of the percentage incidence of a given species in a particular ecomorphological group and in a given biotope correspond mostly with the trends of species abundance in biotopes given by the  $\chi^2$  test of homogeneity  $a_i$  and other computations. For example, as regards the set of species which are significantly more abundant in only one of natural biotopes in view of this test, the percentage incidence of all 17 spider species of group A ( $\%_A$ ) and of 37 out of 39 species of group B ( $\%_B$ ) is highest in the same biotope, as was the one indicated by the homogeneity test (there are only two exceptions: *Goniatum rubellum* and *Hilaira excisa*). Moreover these differences of percentage incidence have been found to be significant in most species of which more than ten individuals have been caught (*G. rubellum*, *H. excisa* - no significance). These significances have been found even in some of the species of which ten or less individu-



als have been caught (*Araeoncus crassiceps*, *Centromerus laevis*, *Tegenaria agrestis*, *Trachochrus scabrichius*)

### Summary of principal results

All spider species determined in the material are listed below together with the biotope with the highest catch of each of species, i.e., the hypothetical optimum biotope, all other biotopes where a species was significantly more abundant in view of results of the  $\chi^2$ -test ( $a_{ij}$ ), the station/stations with the relative high occurrence of some species, the number of caught specimens of each species and some further remarks, the semiarificial (MA) biotope and ruderal (Ru) biotope has been evaluated to be optimum only for species not caught in any other biotope, even if the highest occurrence of a species has been recorded in one of these biotopes (MA, Ru) by the  $a_{ij}$  test or other computations as well

### Explanations.

RS, VQ, (ms. ch, ) = biotope (station/stations) with the highest computed value of occurrence of a particular species, all other biotopes with a similar value of occurrence in view of the  $a_{ij}$  test but in which the species occurs not so frequently in view of other computations (the biotope quoted first is the optimum one) and/or the biotope (station/stations) where a species was caught.

\* species marked by an asterisk = species which is significantly more abundant in the said biotope/biotopes than in all other studied ones in view of the  $a_{ij}$  test; all biotopes with higher abundance of a species determined by this test are always quoted

Cipher (stated in the first part of the list) = actual number of all specimens of a given species captured.

Indices A - E, Z = results of comparison of the detected optimum biotope with postulates of other authors (see "Discussion" for details). Index A = the highest accord, identification with the same and/or very similar biotope and/or its biocoenosis (e the comparative unit); B = accord in view of classification of the biotope and its biocoenosis into thermophilous, mesophilous or hygropsychrophilous ecosystem, and simultaneously accord in a formation, open, shrub or woody; C = accord in ecosystem (thermophilous, mesophilous or hygropsychrophilous); D = accord in formation (open, shrub or woody); E = discord - the author reports only a biotope of a different ecosystem, or a different formation which is not further specified, as preferred, most frequently occupied or frequented solely by a given species; Z = uncertainty i.e. the given author mentions an ecological characteristic but it is insufficient for this classification

Indices a-h = other biotopes and permanent biocoenoses also preferred by a respective species according to findings of other authors; index a = rocks without vegetation, rock walls and/or quarries; b = various other biotopes in mountains; c = coastal herbaceous biotopes and salt-marshes; d = very large open peat-bogs; e = open sandy biotopes and/or open large heaths; f = open sandy xerothermic biotope, occasionally with sparse low vegetation; g = coastal oligo- and mesotrophic vegetation; h = open bogs with *Calluna*, *Ledum* and open heaths.

Table 1. Classification of species with regard to the strata/stratocoenoses where a species predominantly lives (subsets e - v), number of specimens caught (groups 1 - 4) and results of comparison of the determined optimum biotope of a species with other authors' statements (categories A-Z)

e epigeic species, x species living predominantly on the soil surface but partly on vegetation as well, v species living predominantly on vegetation, 1 one specimen, 2 2-10; 3 11-50; 4 more than 50 specimens caught. A maximum accord with most other authors, B - D lower levels of accord; E discord; Z other authors' data are insufficient for this classification

Category	e				x				v				$\Sigma$	%
	1	2	3	4	1	2	3	4	1	2	3	4		
A	0	19	37	46	4	10	7	7	5	7	2		174	46.04
B-D	8	38	34	39	3	8	6	4	6	12	5	1	176	46.56
E	2	4	1	2	-	-	-	-	1	1	-	-	11	2.91
Z	2	3	1	2	1	2	1		2	3	-	-	17	4.49
$\Sigma$	32	84	73	89	10	20	14	11	14	23	7	1	378	100

Values of  $\chi^2$  were 2.40 for 400 years have been met

233

23 Agelenidae (s.l.) \**Cicurina cicurea* (P.) LA<sup>B</sup>, CQp, Ag, Ru, 243 \**Coelotes inermis* L. K. LA<sup>B</sup> PQ TFs, BS, ACp, SA, SG, MC, MA 1 839 \**C. terrestris* (Wid.) TFI<sup>B</sup> CQp, TFs, MC PQ LQ, 3 906 \**Hastipoma armida* (C. L. K.) TFs<sup>B</sup> ACp, TFI, BS, LA, iAC, 788 \**Tegenaria atrica* C. L. K. QP<sup>C</sup> 20 \**T. silvestris* (L. K.) AC<sup>B</sup>, ACp, FS, BS 144 \**Tetrax denticulata* (Oliv.) FS<sup>A</sup>, ACi, VQ, RS, 188 Cybaeidae \**Cybaeus angustiarum* L. K. BS<sup>A</sup>, SA, LA, ACp, 300 Hahniidae \**Anussea elegans* (B.) CA<sup>B</sup> (xph), BS 74 \**Hahnia nana* (B.) RS<sup>A</sup> 11 Amaurobiidae \**Amaurobius fenestratus* (Strom.) LF<sup>B</sup>, TFI, TFs, 214 \**Callobius claustrarius* (Hahn) iAC<sup>S</sup> TFs, SG, TFI, ACp, 462 Titanocoridae \**Titanocora obscura* (Walck.) VQ<sup>C</sup>, RS, DP, QP, 38

Table 2. Anethological classification of stations based on the discrimination rule

RS - Ru biotope categories, in some of them two similar biotopes are summarized, semantificand MA biotope is omitted).  $j$  - actual biotopes where the samples were taken,  $j^0$  - biotopes determined by the discrimination,  $m$  - number of stations in biotope  $j$ , figures in the  $j^0$  quadrate = numbers of stations (or samples) for which the given biotope (biotope category) is hypothetically optimal (the determination is based on the  $'N^{(j)}_k$  criterion, total numbers 0 5, 1 5, 2 5, 3 5 in the respective samples: there are couples of species subsets with the identical  $'N^{(j)}_k$  values), \*  $j$  - vm,  $j^0$  - TFI,  $j^0$  - TFI

$j^0$	RS	DP	QP	VQ	CQp	LQ	FS	ACi	iAC	ACp	MC	LF	TFi	BS	SA	Ag	Mh	St	Ph	SG	Ru	$m_j$
					+CQp	+PQ				+LA			+TFs		+CA							
RS	4	-	-	1	1	1	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	9
DP	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
QP	-	-	3	1	-	1	-	-	-	-	-	-	1*	-	-	-	-	-	-	-	-	6
VQ+CQp	-	1	-	5	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	8
CQp	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
LQ+PQ	-	-	-	-	1	3	-	-	-	-	-	-	1*	-	-	-	-	-	-	-	-	5
FS	-	-	-	-	-	-	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	6
ACi	-	-	-	-	1,5	1,5	-	2	0,5	-	-	-	0,5*	-	-	-	-	-	-	-	-	6
iAC	-	-	-	-	-	1	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	5
ACp+LA	-	-	-	-	-	-	-	-	3,5	4	-	-	1,5*	-	-	-	-	-	-	-	-	9
MC	-	-	-	-	-	2,5	0,5	-	-	2	-	-	4*	-	-	-	-	-	-	-	-	10
LF	-	-	-	-	1	-	-	-	-	-	-	4	1*	-	-	-	-	-	-	-	-	6
TFi+TFs	-	-	-	-	-	1*	-	-	2	2	-	-	8	-	-	-	-	-	-	-	-	13
BS	-	-	-	-	-	-	-	-	-	1	-	-	-	5	-	-	-	-	-	-	-	6
SA	-	-	-	-	-	-	-	-	1,5	3	-	-	-	2	4	0,5	-	-	-	-	-	11
Ag+CA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	3
Mh	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-	-	-	8
St	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	3
Ph	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
SG	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	3	-	5
Ru	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1

Lioctronidae: \**Lioctronum ruficula* (Walck.) FS<sup>4</sup>, 40 \**Agruena brunnea* (Bl.) QP<sup>4</sup> (m, vm), SG, PQ, MA, 222 \**A. cuprea* Mge VQ<sup>4</sup> CQp, RS, 49 \**Apanteles fuscus* Wesm. ACt<sup>4</sup>, ACp, LA, LQ, QP, FS, 219 \**Phrurolithus festinus* (C. L. K.) RS<sup>4</sup> QP, MA, 24 Clubionidae: \**Clubiona terrestris* Westw. TH<sup>4</sup>, MC, 35 Zodariidae: \**Zodariion germanicum* (C. L. K.) RS<sup>4</sup>, FS, LP, 25 Gnaphosidae: \**Callilepis schuszeeri* (Her.) FS<sup>4</sup> (m, th), RS, 37 \**Drassodes cupreus* (Bl.) DP<sup>4</sup>, VQ, FS, MA, 14 \**D. lapidarius* (Walck.) FS<sup>4</sup> (th), RS, DP, ACt, 311 \**D. pubescens* (Thorel) RS<sup>4</sup>, MA, Ru, 45 \**Gnaphosa bicolor* (Hahn) ACt<sup>4</sup>, VQ, LF, FS, 32 \**G. lucifuga* (Walck.) RS<sup>4</sup>, 16 \**G. lugubris* (C. L. K.) RS<sup>4</sup>, DP, 34 \**Haptodrasus signifer* (C. L. K.) RS<sup>4</sup>, VQ, QP, MA, 65 \**H. silvestris* (Bl.) LP<sup>4</sup>, PQ, MC, RS, MA, 149 \**H. toerensis* (Strand) LP<sup>4</sup>, ACt, LQ, MC, VQ, QP, 07 \**H. umbrinus* (L. K.) QP<sup>4</sup> (cvs), VQ, Ru, 37 \**Micaria fulgens* (Walck.) QP<sup>4</sup> (nu), DP, RS, VQ, 49 \**Z. aurantiacus* Miller CQ<sup>4</sup>, QP (nu), DP, VQ, 49 \**Z. electus* (C. L. K.) RS<sup>4</sup> (sj), 19 \**Z. areolaris* (Thorel) FS<sup>4</sup> (th), ACt, VQ, 11 \**Z. exiguus* Miller et Schenkel RS<sup>4</sup>, 8 \**Z. furcifer* (Sim.) Mh<sup>4</sup>, Ru, 12 \**Z. haematus* (L. K.) St<sup>4</sup>, Mb, Ag, Ru, 63 \**Z. petrensis* (C. L. K.) RS<sup>4</sup>, QP, VQ, 227 \**Z. praefluat* (L. K.) RS<sup>4</sup>, QP, 12 \**Z. purpuratus* Chamberlin RS<sup>4</sup>, VQ, DP, 37 \**Z. subterraneus* (C. L. K.) LQ<sup>4</sup> QP (nu), FS, VQ, LP, ACt, MA, 172 \**Z. villosus* (Thorel) DP<sup>4</sup>, RS, FS, ACt, 72 Zoridae: \**Zora manicata* Sim. RS<sup>4</sup> CQ<sup>4</sup>, VQ, 20 \**Z. nemoralis* (Bl.) ACt<sup>4</sup> LQ, VQ, PQ, 30 \**Z. silvestris* Kulcz. RS<sup>4</sup>, VQ, 16 \**Z. spinimana* (Sund.) Ag<sup>4</sup> CA, SG, LQ, QP, MA, 63 Philodromidae: *Philodromus collinus* C. L. K. SG<sup>4</sup>, 11 Thomisidae:

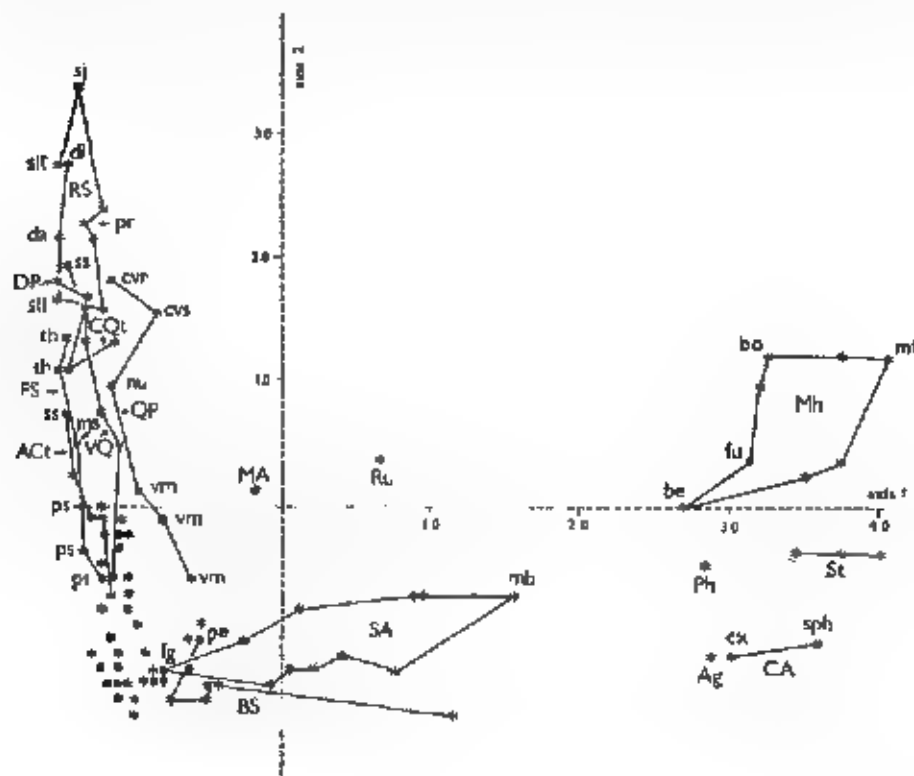


Fig. 1 Ordination of samples of 126 stations based on correspondence analysis of the abundance values of individual spider species in canonical coordinates 1 and 2. The diagram shows similarity of samples and/or stations with regard to the distribution of spider abundances (the distance between samples is positively correlated with their dissimilarity). Asterisks = individual samples, dots = almost identical position of two or more samples, letters = biotopes and stations, complexes of samples joined by lines = all samples belonging to the respective biotope (only the biotopes and stations most differing within the whole configuration are denoted by lines and letters).



(Mge) DP<sup>c</sup> \**Xysticus lunus* (C. L. K.) PQ<sup>c</sup>, AC X *stranipes* L. K. RS<sup>a</sup> X *uhm* (Hahn) Mh<sup>a</sup> Salicidae *Ballus depressus* (Walck.) VQ<sup>a</sup> *Euphyrys asquipes* (Q. P. Cbr.) RS<sup>a</sup> *E. frontalis* (Walck.) Qk<sup>a</sup> (nu) *E. perrensis* C. L. K. VQ<sup>a</sup> *Evarcha arcuata* (Ct.) Mh<sup>a</sup> *E. lactabunda* (C. L. K.) RS<sup>a</sup> *Heliophantus capreus* (Walck.) RS<sup>a</sup> *H. muscorum* Walck. FS<sup>a</sup> CQ<sup>a</sup> *Neon laevis* (Sim.) FS<sup>c</sup> (th) *N. reticulatus* (Bl.) AC<sup>a</sup> *Pellenes nigriculatus* (L. K.) RS<sup>a</sup> *P. sinuatus* (Walck.) RS<sup>a</sup> *Phalaena chryseus* (Poda) FS<sup>a</sup> (th) *Salticus scenicus* (Cl.) RS<sup>c</sup> *Salticus pubescens* (F.) VQ<sup>c</sup>

Table 3. Classification of spider species with regard to their optimum biotope and results of comparison of the optimum biotope of a species with other authors' statements.

RS - Ru biotope categories (in some of them two similar biotopes are summarized; semiartificial MA biotope is omitted). A - maximum accord with most other authors; A - D - lower levels of accord; E - discord; Z - other authors' data are insufficient for this classification.

Biotope	A	B, C, D	E	Z	Σ
RS	48	18	1	-	67
DP	4	4	-	-	8
QP	17	11	-	1	29
VQ+CQ	1	15	2	1	19
CQp	1	2	1	-	4
LQ+PQ	-	10	2	2	14
FS	9	11	1	4	25
AC	2	8	1	-	11
AC	-	4	-	1	5
ACp+LA	2	15	-	-	17
MC	2	8	2	2	14
LF	5	6	1	-	12
TPi+TPi	8	3	-	1	14
BS	4	1	-	-	5
SA	1	8	-	2	11
Ag+CA	17	11	-	-	28
Mh	31	15	-	2	48
St	5	9	-	-	14
Ph	3	6	-	-	9
SG	11	7	-	1	19
Ru	3	1	-	-	4
Σ	174	175	11	17	377

The correspondence analysis of the whole material demonstrates chiefly the heavy differentiation of the distinctly (xero-)thermophilous biotopes (the complex rock steppe biotope including) and the hygropsychrophilous ones, this differentiation accords with general characteristics of various individual stations of these biotopes (cf Fig. 1, see RS - sj, slt, di, FS - both th stations, all ps stations, etc.).

## DISCUSSION

### Comparison with other authors' statements about quantitative differentiation of spiders in terrain

#### a) General principles of the processing

The results were compared with data in 179 publications of Czech and Slovak as well as foreign authors who had either treated the entire arachnofauna of a given territory in comprehensive studies based on their own research and using many sampling methods (i.e., not only pitfall trapping) and on collation of the works of others (Buchac 1989, Grtman 1983, Marus 1981, Miller 1971, Proszynski & Starega 1971, Schaeffer 1976, Treitzel 1952, Wicher 1953, 1956, 1960, etc.) or investigated specific ecosystems and relatively rare species. In case of the former authors we took into account their data on the ecology of all the spiders given in these publications. We evaluated a total of 3 906 statements of other authors.

The comparison was simplified by the optimum biotope hypothesis. We may consider, on the basis of our computations, that each spider prefers only one biotope in one biotope spectrum, which could be considered the hypothetically optimal biotope. When a very small number (down to only one specimen) of a given species was captured, we considered that biotope a hypothetically optimal too. We have natural biotopes considered superior as relative to the semianificial (MA) and disturbed (Ru) biotope.

Higher ecological units than individual biotopes with their bioconoses had to be used for comparison in many cases in view of the manner of ecological specification implemented in most fundamental arachnological publications. All basic comparative units represented in our material are denoted in the chapter "Study area and sampling sites" by headlines in the list of sampling sites (6 unscripted), other units quoted in the studied publications but not represented in our study are chiefly biotopes quoted above in the remarks on the "Summary of principal results" (see indexes a - h) and aspen, birch, poplar, moist oak and moist pine woods as well "Mycophiles woods", unspecified by other authors, were compared only at formation level, because various beech forests and woods in the KBR lie especially in cool biotopes.

Then we always tried to establish only the degree of accord of the optimal biotope with the biotope or environment mentioned in the given paper/papers as preferred, most often occupied or exclusively frequented by the given species. Three levels of accord were applied, the highest level of accord was always registered, for categorization, see the "Summary of principal results" (indexes A - D, Z).

#### b) Comparison with each individual paper

With each spider species, the hypothetically optimal biotope was compared with statements in each of the most important papers dealing with a given species, i.e., each of the 3906 statements in papers of other authors was classified separately. If two or more preferred biotopes or factors were mentioned in the paper we based the comparison on the locality which agreed best with the hypothetically optimal biotope (e.g.,  $A + B = A$ , or  $A + B = A$ ,  $B + C = C$ , etc.) and the procedure was the same if the biotopes had not been specified (e.g.,  $\text{maximal environment} = \text{accord in formation} = C$ ). The statements concerning each species in each of the papers were then always expressed by only one symbol.

Mostly ten papers were used for comparison per species, the average number of papers used per species was 7.0 for species living predominantly on vegetation and represented by more than 50 specimens in the material, up to 12.5 for epigeic species of the same abundance value, applying the system of classification of material into 12 groups based on the abundance and basic way of life (cf. table 1, columns #1 up to #4). The numbers of papers differed only by

words if the results based on pitfall trapping were removed from the set. The proportion of studies with B+C+D results is large: the ratio of the numbers of results A : B+C+D : E was approx. 10 : 80 : 10 %.

c) Comparisons with these theses constructed by the synthesis of other authors' statements

The statements of many authors on the ecology of the species are rather general, or only some environmental factors have been specified. Therefore, we also used another comparative method reducing the spectrum of statements in such a way that other authors' statements from all studies relevant to each spider species were empirically synthesized into the form (thesis) of the highest specification level according to the data by the majority of leading authors (e.g., moist environment, wind = moist winds, etc.). The hypothetically optimal biotope of each species was then compared with the respective thesis, and the result was to cover the whole thesis at the highest level (e.g., *Arypus affinis* optimal biotope = R5 other authors' prefers warm, dry and open biotopes, particularly rock steppes and pine winds, result = C), specified biotopes not recurring in central Europe were classified only at the level of categories B - E. Z. Also, some negative findings of other authors (46 papers, 39 spider species) made the thesis more precise. In this synthesis the highest degree of accord (A) has been also documented in eleven further species, although it does not ensue from any single paper dealing with them, and it has been lost in nine species where it was found previously.

In total, the number of species where the highest degree (A) of accord with the observations of other authors had been documented increased to about 46.0 %. Almost half of the spectrum of species collected (46.6 %) are also species where accord has been documented at least at the level of ecosystem and formation. Only 2.9 % (i.e. 11 species) are species in which our findings are at discord with most of the views of other authors, most of them (9 spp.) are represented in total material only by 1 - 17 individuals, the remaining two species, *Lepthyphantes pallidus* and *Mesometes rurestris* are more frequent (15 and 128 individuals) but specific causes of this discord can be admitted (i.e. *pallidus*: insufficient description of optimal environment in the papers of other authors; *M. rurestris*: massive aerotaxical transport upon prominent rocks).

Also, we examined the reduction of relevance of results for these comparisons due to small number of specimens of a particular species and/or to its preference of other strata/stratifications. Therefore the results were partly summed up (see Table 1) and the numbers of species in the respective subsets and groups were compared.

There is no difference between the number of species which were represented by less or less specimens and the number of species with 11 or more specimens with regard to the frequency of species with the highest degree of accord (A); there is a significant difference between the number of species represented by only one specimen and the sum of other species with this regard, but the value of significance is close to the significance threshold ( $N=15$ ,  $\chi^2=1.97$ ,  $\alpha=0.05$ ). The highest degree of accord (A) is significantly more frequent in the subsets of species living exclusively or prevalently on the ground (i.e. subset e + x in Table 1) than in the species living predominantly in upper strata (subset v in Table 1), although even in this case the differences are near the threshold of significance, especially when comparing subsets x and v, there is no difference between subsets e and x with regard to A-frequency (e/v:  $\alpha < 0.04$ , x/v:  $\alpha < 0.05$ ,  $\alpha/\alpha$  is 100 %). It is possible to suppose, however, that the few captures of specimens in subset v (only 8.7 % of the whole material) is the only cause of the low significance.

Finally, we examined the relevance of the classification of individual samples by the relative representation of species, each of which is taken as a representative of (a) its optimum biotope for the determination of a respective biotope from which the sample was taken, as well as for the identification with the respective station. Therefore the results were employed in an



arachnological classification of stations, based on the sample discrimination rule (see Table 2). The efficiency of this classification of the given samples is very reliable (Table 2: maxima of values are concentrated in the Lagonal). Deviations are caused principally by the erroneous classification of samples in *Cynancho Quercetum poetosum* and loamy *Tilio-Fagetum*, this fact can confirm opinions that both these habitat types are transitional from the synecological standpoint (cf. Šmaha & Pěnička 1989). Classification of spider samples into *Melampyro-Carpinetum* seems to be problematical but difficulties can also be caused by the diversity of this association, our MC stands including. For example, the facies fm with *Fraxinus excelsior* and *Mercurialis perennis* was theoretically identified by means of our spider samples with the *Lunario-Aceretum*, which is included in the same phytocoenological alliance as the *Mercuriali-Fraxinetum* association. The dispersion of RS and SG spider samples in Table 2 reflects adequately the character of stations, while samples from the most typical stands (RS: all four stations on basic substrate d, sj, slt, slt; SG: all three stands where there were allegedly spruce trees before cultivation as well) have been exactly classified.

With respect to assessments quoted by other authors, above all, the results in 104 species in categories B - Z, especially in those species of which more than ten species were caught and which were more abundant in some biotopes in view of the  $\chi^2$  homogeneity test, need to be taken into consideration as newly ascertained qualities.

There is also the remarkable equality of incidence of some species in different biotopes (without significant differentiation of their abundance), which can also document the connexion of these species with a special biotope and/or stratum of substrate - e.g., the species *Segestria senoculata*, *Walckenaeria dysderoides*, *W. obtusa*, *Pisaura mirabilis*, *Evarcha falcata*. This connexion can be cause of some discrepancies between our results and those of other authors in some species (*W. dysderoides*).

#### Differences in mechanical permeability of environment

The results of our sampling and processing method have demonstrated that differences in abundance and incidence of spiders are predominantly correlated with factors other than mechanical permeability. Theoretically, it is impaired by stones, grasses, etc. or the value of the horizontal penetration activity, typical of individual species.

Comparisons of optimal biotopes for individual spider species with the postulates of other authors, who had used various methods for collecting spiders, resulted in an accord of our results and most other authors' postulates in 92.6 % of the whole species spectrum. Other facts could also be taken into account: no congruity has been proved in general between differences in the level and frequency of accord with these authors and differences in superficial structures of soil surface of a biotope, as they are given in biotope characteristics (cf. Tables 2, 3); accord of the significant differences of percentage incidence of spider species in the catch of respective ecomorphological groups with the trends given by the results of other computations; results of the correspondence analysis as they were shown (for various mesophilous biocoenoses see, e.g., the results of the scaling method, Šmaha & Pěnička 1989).

### Application of results in general biocoenological research and in estimating anthropogenic impacts

A precise arachnological assessment can be made with complete samples, by comparing them with the standard by ordination of the similarity values in at least a two-dimensional space. The scaling of similarity values of complete samples is evidently more precise than the correspondence analysis in view of differentiation of communities which do not deviate much from the ecological medium, and some of extreme biotopes (e.g., fields of scree) as well (cf. Šmaha & Pěnčík 1989). Nevertheless, special programming equipment and qualification are a prerequisite to using both these methods and some others similar in complexity; many arachnologists will probably continue to make simpler direct analyses of samples by means of ecological classification of individual spider species.

Therefore, the determination of optimum biotope for spiders and the  $\chi^2$ -test can be applied for evaluating possible differences of a studied environment from other biocoenoses or elementary units by comparing the results in question with the present ones, shown in Table 2, biotopes CQp, TPI and 11 spider species, the optimum biotope of which was not obviously found, while it discords with the majority of other authors (see "Summary of principal results", species marked with the index E); should be then omitted.

The results presented in this study can be applied to many other biotopes and biocoenoses, particularly in central Europe, with similar properties as have the ones presented here. However, biotope preferences of various species whose ecological optima are in another altitudinal zone and whose centres of occurrence are beyond the biogeographic region of central Europe can be diminished in comparison with our region - e.g., *Callobius claustrarius* (cf. Braendegaard in Bucher 1972, Thaler 1980), *Hilaria excisa* (cf. Braun in Bachr 1985), *Zelotes pumilus* (cf. Platnick & Shadab 1983).

Arachnological analyses can also effectively contribute to general characterization of various biocoenoses and habitats and also make it more accurate, as can be demonstrated by our results.

### CONCLUSIONS

The principal results are presented here of a study of the quantitative differentiation of spider occurrence in many stations of a relatively wide spectrum of biotopes with xerothermophilous to hygropsychrophilous biocoenoses; the study is based on pitfall trapping.

Testing homogeneity of spider abundance in biotopes indicated that 75 species of a total of 378 determined species are significantly more abundant in only one biotope and 152 species in two up to eight biotopes of a series of 25 natural biotopes.

Homogeneity tests and other computations, or the record of mere presence (finding of several down to one specimens) denoted, in all 378 species, only one biotope with the highest occurrence of the spider that could be considered optimum biotope.

In the comparisons, we used 3 906 ecological statements of other authors and found full accord of our findings and theses with those of other authors in almost half of the species, accord at lower levels (the lowering being caused mostly by lack of exact data in arachnological literature) in almost the same proportion of species spectrum, and discord in mere 29 % (11 species).

The frequency of the highest accord in identification of the optimal biotopes with the statements of other authors was not significantly lower even in species which were represented by ten or less specimens and in species living temporarily on herbs or in higher strata; it was lower

in species living on herbs or in higher strata predominantly, but the difference was close to the significance threshold.

A majority of samples of individual stations were exactly classified by means of a discrimination based on the simple computation into the identical natural biotope with respective plant association where there were collected. We failed in this classification only in a few cases of transitional biotopes with *Cynancho-Quercetum poetosum* subassociation and the loamy forest type of submontane *Tilio cordatae-Fagetum*, spruce stands of the *Equiseto-Abietetum* habitat types where allegedly no spruce took part before artificial changes, complex stands of *Melampyro-Carpinetum* and some small stations of the complex rocky steppe biotope considerably influenced by their surroundings.

Ordination of samples based on the canonical correspondence analysis of abundance values of individual spider species shows that the arachnological differentiation of various stations of (xero-)thermophilous biotopes (rocky steppes including) as well as hygropsychrophilous ones accords with the basic characteristics of the environment.

The results of mathematical processing of our material and of comparison with other authors' statements demonstrate that the efficiency of the pitfall method used as regards identification of the preferred or optimal biotope was not impaired by differences in the penetration activity of the individual species and in the mechanical permeability of the environment given by the details of surface structuring.

We can contribute to a better assessment of natural communities preferred by individual spider species, especially by 104 species whose abundance in natural biotopes is significantly differentiated and whose ecological preferences have been hitherto very differently specified by other authors or are insufficiently known (above all, 86 species of which more than ten specimens were caught).

The simple discrimination based on the results and relevant analysis of samples for evaluation of biota and biotope changes is presented.

The results can also be applied to various other homologous communities. They prove that arachnology can make a substantial contribute to the biocoenological classification and applied ecology as well.

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## APPENDIX 1

### Notes on mathematical processing

#### Basic terminology

- $N_k$  number of species in  $k$ -th station of biotope  $j$ ;
- $N_k^j$  number of all species in our material for which biotope  $j$  is the optimal one with respect to the discrimination results;
- $N_k^{j*}$  the number of species of the species subset of the  $j$ -th station sample, for which the biotope where the sample was taken is optimal;
- $N_k^{(u,y)}$ ,  $N_k^{(y,u)}$  the number of species of the  $j$ -th station sample for which the biotope  $u$  or  $y$ , i.e. different from that of which the sample was taken, is the optimal one ( $u \longleftrightarrow y$ );
- $\bullet N_k^{(u,y)}$  the maximal value of the relations  $N_k^{(u,y)}/N_k^{(y,u)}$ ,  $N_k^{(y,u)}/N_k^{(u,y)}$ ,  $N_k^{(u,y)}/N_k^{(y,u)}$ ;
- $n_j$  total number of specimens of species in biotope  $j$ ;
- $n_j^A$  number of spiders of ecomorphological group  $A$  in biotope  $j$ ;
- $n_j^B$  number of spiders of ecomorphological group  $B$  in biotope  $j$ ;
- $r$  number of biotopes;
- $x_j$  number of traps in biotope  $j$ ;
- $z$  total number of traps.

$\%_A = 100 \cdot a_{ij} / n^0$ ,  $\%_B = 100 \cdot a_{ij} / n^0$  — percentage incidence of a species  $i$  in particular ecomorphological group  $A, B$  and in a given biotope  $j \longleftrightarrow u$ ;  $i \in A, (i \in B)$ .

#### Testing methods

The following are the homogeneity tests: the method of good fitness used (tests of independence were widely applied too);

a) tests of relative abundance in biotopes: differences in relative abundance are found using the test based on the supposition that the selection of the total number of specimens caught in particular biotopes ( $a_{11}, \dots, a_{1r}$ ) has a multinomial distribution with parameters  $r$

and  $p_1, \dots, p_r$ , where  $p_i = z_i / z$ .

$a_{11}$	$a_{1r}$
$a_{21}$	$a_{2r}$

contingency table, compared values

Application of the results of the optimum biotope discrimination to the classification of samples (Tab. 3). The subset ( $N_{j_1}^{(u)}, N_{j_2}^{(u)}, \dots, N_{j_r}^{(u)}$ ) whose value of the criterion " $N_{j_1}^{(u)}$ " is highest of all other subsets of a given sample determines the biotope  $j^{(u)}$  of a sample.

**New species of *Anthaxia* from China (Coleoptera: Buprestidae)**

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**Taxonomy.** *Anthaxia cyanconigra* sp. n., China

**Abstract.** *Anthaxia (Melanthaxia) cyanconigra* sp. n. is described, illustrated and compared with related species.

***Anthaxia (Melanthaxia) cyanconigra* sp. n.**

**DESCRIPTION.** Large, flat, rather lustrous species without sexual dichromatism: whole body black, prosternum with bronze, metasternum and abdominal sternites with blue lustre. Lateral frontal margins sometimes with blue tinge, frons anterior pronotal angles and ventral side of body with long, elytra with short pubescence, frontal pubescence bicolorous: basal part of hairs darker, brown or black, distal part grey. Pubescence of elytra and ventral side light grey. Head relatively small, anterior margin of clypeus slightly, roundly incurved, frons slightly vaulted, with more or less distinct longitudinal groove and with two transversely situated small rounded depressions, vertex wide, about 2.0 times wider than width of eye, structure of head consisting of small rounded and polygonal cells without distinct central grains, antennae rather long, about 1.3 times longer than length of pronotum, antennal segments 4-5 triangular, segments 6-10 trapezoidal, somewhat longer than wide, last antennal segment shortly elliptical.

Pronotum wide, 1.8-2.1 wider than long, with shallow medial groove which is more distinct only in posterior third and with two rounded depressions, situated transversely before middle of pronotum, laterobasal pronotal depressions prolonged anteriorly and form two oval depressions in middle of pronotal length [pronotal depressions resemble these in *A. quadripunctata* (Linnaeus 1758)], structure of pronotum consisting of polygonal cells with large central grains laterally: cells are transversely prolonged in middle part of pronotum and their sides form transverse wrinkles, roundly bent toward medial groove, anterior part of pronotum with irregular grainy structure, each half of pronotal base with smooth, small lustrous field, pronotal shape very variable (Fig. 3). Scutellum pentagonal, as long as wide.

Elytra subparallel, slightly enlarged at two third of their length, 1.7-1.8 times longer than wide, tapering part of elytra (apical third) slightly rounded, with indistinct lateral serration, elytral epipleurae narrow, almost reaching elytral apex, elytra uneven, with several shallow depressions, elytral structure with somewhat rough, regular granulation: elytra more lustrous than pronotum.

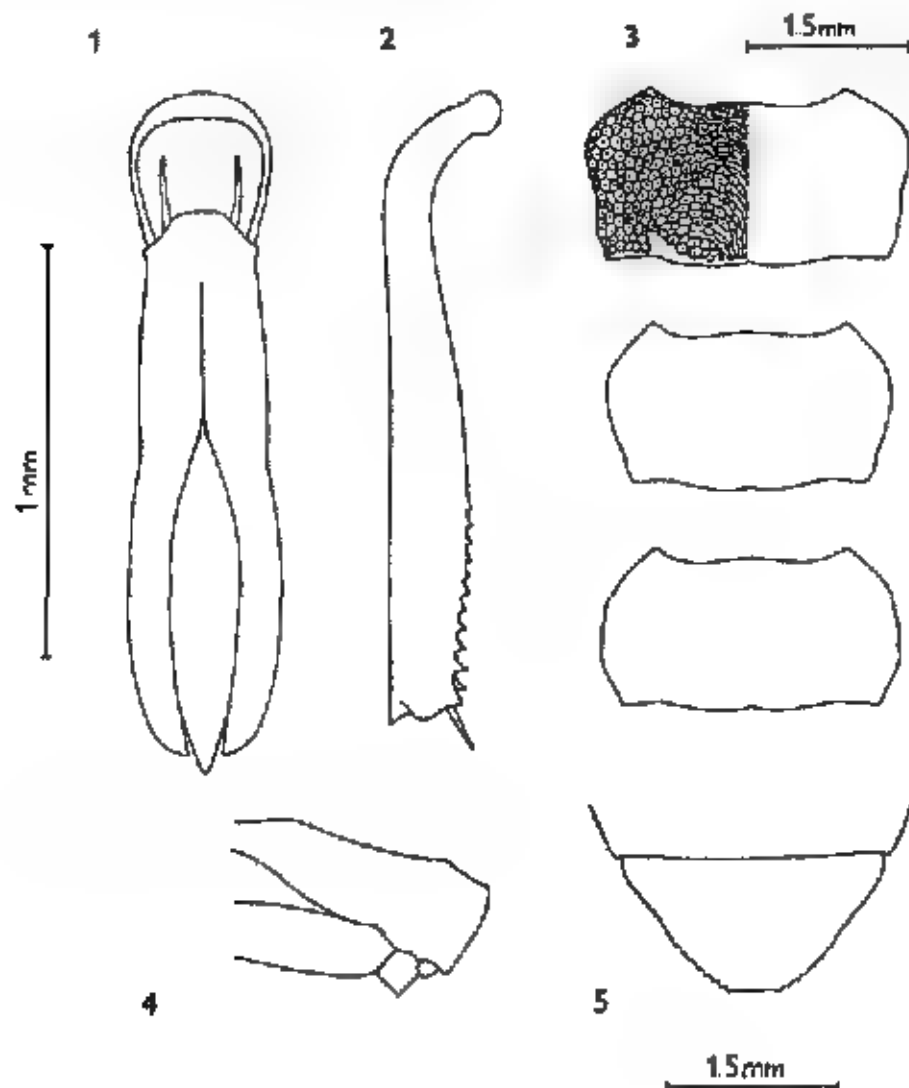
Ventral side of body lustrous, finely ocellate, structure of prosternum somewhat more distinct, metatrochanters of male with small, blunt spine (Fig. 4), anal sternite simply rounded apically, lateral margins very slightly S-shaped and shortly serrated before apex in both sexes (Fig. 5).

Legs relatively short, tibiae straight, male meso- and metatibiae with well developed inner serration in apical third (Fig. 2) tibiae of females not modified.

Aedeagus (Fig. 1) short and robust, slightly enlarged in apical half.

Sexual dichromatism undeveloped

Length 6.75-8.30 mm (holotype 7.00 mm), width, 2.60-3.30 mm (holotype 2.90 mm).



Figs 1-5 *Anthrax (Melanikara) cyanonigra* sp. n. 1 - aedeagus; 2 - male metatibia; 3 - structure and variability of pronotum; 4 - metatrochanter of male; 5 - anal sternite.

Host plant *Larix* sp.  
DISTRIBUTION China, Yunnan

TYPE MATERIAL. Holotype (male): China, Yunnan, Zhongdian, 1994 (ex larva), E. Kučera leg. Allotype (female): China, Yunnan, Zhongdian, 16-21 vi. 994, E. Kučera leg. Paratypes (3 males, 10 females) the same data as in holotype (3 males, 1 female); the same data as in allotype (2 females); China, Yunnan, Zhongdian, 17-19 vi. 995, E. Kučera leg. (7 females). Holotype in the collection of E. Kučera, allotype in the collection of the author, paratypes in the collection of the National Museum, Prague, E. Kučera and the author.

DIFFERENTIAL DIAGNOSIS. *Anthaxia cyaneonigra* sp. n. belongs by its pronotal structure and relatively long grey frontal pubescence to the *A. reticulata* Motschulsky, 1859 species group (Richter 1949). It also resembles by its pronotal structure *A. acutangula* Motschulsky, 1860 and it differs from it by darker frontal pubescence (white or grey in *A. acutangula*), by more developed pronotal wrinkles, by straight male metatibiae with distinct inner serration (male metatibiae slightly bent inward, with indistinct serration in *A. acutangula*), by well developed laterobasal depressions (undeveloped in *A. acutangula*), by shorter and robust aedeagus and by colouration of ventral side of body (black with bronze lustre in *A. acutangula*).

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**Mating behaviour of *Aphodius (Chilothorax) distinctus*  
(Coleoptera: Scarabaeidae: Aphodiinae)**

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**Phology, mating behaviour, Coleoptera, Scarabaeidae, Aphodiinae, *Aphodius distinctus*, Central European population**

**Abstract.** Field observations made in localities in Bohemia, Moravia and Slovakia and supplemented by those of captive beetles have been used to reconstruct the course of the mating behaviour of *Aphodius (Chilothorax) distinctus* (O. F. Müller, 1776), from the moment a male finds a female up to their copulation. The phenomenon of chained pairs moving over the surface of dung is described in detail. The conditions under which this occurs on the surface or inside of the dung pads, and whether the moving of pairs of *A. distinctus* in the chained position over the surface or the dung is exceptional within the genus *Aphodius* Liger, 1798, are among the problems discussed. The importance of the successive phases of the mating behaviour is hypothesized for other *Aphodius* spp. showing similar monomicty, the same as their mating strategy and the linkage between copulation and oviposition. The discussion also touches the problem of the number of generations produced by *A. distinctus* within the year and the methods of observing the mating behaviour of non-nesting Scarabaeoidea.

INTRODUCTION

So far, the reproductive behaviour of coprophagous Scarabaeoidea has been studied in greater detail only in the subfamily Scarabaenae (see Halfiter & Matthews 1966, Halfiter & Edmonds 1982). More detailed descriptions of the mating behaviour of the members of the subfamily Aphodiinae are more or less non-existent. Only Schmudt (1935: 333) describes the mating behaviour in the genus *Aphodius*: "Die Männchen sieht man dann oft zu mehreren hinter einem Weibchen herkriechen. Nach einigen vergeblichen Versuchen, bei denen die Männchen vom Weibchen abgerutscht sind, findet dann die Begattung statt." However, it is not quite clear under what conditions the author observed the beetles, as he only states: "Ehe die zur Zucht bestimmten Tiere in den Blumentopf gesetzt wurden, kamen sie auf einige Tage in flache Biechschachteln, in denen die Copula besser als in den grossen Töpfen beobachtet werden konnte", moreover, his text does not show clearly whether his observations involved *Aphodius fimetarius*, *A. distinctus* and *A. prodromus*, or just one of these species (Schmudt 1935: 293-333-334). Landin (1961: 194) states that he observed sexual promiscuity (his text suggests that this was probably a field observation) in *A. quadriguttatus*, *A. distinctus* and *A. sphacelatus*, but he gives no particulars.

MATERIAL AND METHODS

This paper reports on all author's observations of the mating behaviour of *A. distinctus* made in 1985 to 1991 within his faunistic investigations on coprophagous Scarabaeoidea made exclusively by individual sampling.

In observing their mating behaviour on the surface of dung pads in the field, the beetles were not disturbed, save for a single exception (see part A2). They were observed at a distance of about 50 to 100 cm. Observations made at excrement were made by carefully taking them into pieces by hand.

In most cases, including observations made on captive beetles, tentative readings of temperature were made for about five minutes (uninterrupted in captivity) by a non-calibrated thermometer. In the field the air temperature was measured by a thermometer lying on the ground, in measuring soil temperature, its lower end was pushed into the soil about 5 cm deep. In captivity, the lower end of the thermometer was inserted into the excrement about 1 cm deep. When taking these measurements, the thermometer was not shaded (unless otherwise stated).

The rapids beetles were kept in glass jars 250 cm<sup>3</sup> in volume, covered by perforated metal lids, in which I sampled in the place where they were collected. The earth filled roughly three quarters of the volume of the jar, pieces of the excrement in which the beetles were found were added to its upper surface. The jars were placed in a room with ambient air temperature around 10°C. Observations on captive beetles were made in open glass cages with metal frames, for particulars see Observations, part B.

The terms "male", "female" and "pair" used in descriptions of observations of pairs of larger numbers of beetles moving in the chained position, should (but for exceptions) be taken as an interpretation licence, as the observed beetles were not sexed in most cases. If their sex was determined, this fact is explicitly stated in the text (see Observations, parts A2 and B1).

P. Štrba is the author of all photographs. They were taken with a Rollei-flex SL 35 (optics Oberkochen), three National PB 300 flashlights with National releases, on Ilford FP 4 film. P. Morávek made the film shots using a Leica Super camera and Agfa 58 colour film. The negatives of the photographs are deposited in coll. Štrba, the film footage in coll. Morávek.

Unless otherwise stated, I am the author of the observations. The nomenclature was adopted from Kříž (1993). The numbers following the names of localities indicate quadrats of the 2nd map of the former Czechoslovakia, used in mapping the insect fauna (Zelený 1972). Time data refer to CET.

## OBSERVATIONS

**Terminological note:** In the text to follow, I have employed the terms "chained position", "incomplete precopulatory position" and "complete precopulatory position". The first term is explained in part A1. The term "incomplete precopulatory position" denotes the situation in which the male has already mounted the resting female (the precopulatory position and copulation take place in resting, not in moving; the beetles copulate in a position with heads pointing in the same direction) but his hind legs touch the substrate (during copulation, the female may rest even on a slanting or vertical part of the substrate) and the abdomens of the two individuals are mutually separated so that copulation cannot immediately take place. In the "complete precopulatory position" the mounted male holds the female with all pairs of legs and their abdomens are so close that, after a minor change in the male's position, copulation can immediately take place. Using the term "precopulatory" is a schematization, see part 2 of the Discussion.

### A. Field observations of the course of the mating behaviour

This part contains observations during which it was possible to follow the course of the mating behaviour either systematically or only fragments of it. The records have been arranged chronologically.

1 Slovakia, oec., Kuchyňa (7568 69), 12 x 1985, about 300-350 m a.s.  
CIRCUMSTANCES: A pasture on a slope close to the village in the direction to Vysoká Huta (Male Karpaty Mts), mostly facing W and NW, rugged terrain, cattle droppings. Observations made between 9:30 and 12:00 h (mating behaviour observed roughly between 10:00 and 11:30 h). Overcast (intermittent periods of drizzle during preceding night) clearing up from ca. 11:30 h and bright sky after 12:00 (thus, mating behaviour observed during the overcast period). Air temperature at 9:30 h: 17.5°C, at 12:00: 21.5°C.

OBSERVATIONS: More than 100 specimens of *A. dufouri* were found moving over the surface of about forty quite fresh cattle cake-like droppings ca. 15-30 cm across and 3-5 cm thick, probably produced the same morning or the preceding evening (marshy consistence, crust not yet developed, with just a thin skin on the surface). In about 30-40 cases the walking female was followed by a male that held it with his fore legs at the outer margin of elytra in their distal third part (this situation is referred to below as the "chained position" or "chain" and walked (was not dragged) behind the female. In about ten cases, one female was the object of almost simultaneous attempts of two to



under the reproduction. Eight pairs were collected and three were dissected; the last individuals were female; the other ones male, observed at 10.00 h. Various chains of ants that two individuals were not found.

I observed chains of pairs emerging from beneath the crust of the dung through openings or minute fissures. Having walked over the surface of the dung for some time (see below), these pairs crawled under the crust again. At least twice did I observe pairs that formed the "chain" when the male met the female on the surface of the dung pad. In any case the male and female sliding off the female when pair was collected and tried to get the chain back; the male getting in front of the female and walking over the dung in front of her without attempting to grasp her again. In one case two individuals that on the surface of the increment and mutually "nodded" their heads and prolegs, moving the outspread segments of antennal clubs in their immediate proximity. (I failed to determine whether they touched and touching their bodies so that they also could "nod" the abdomen of the partner.) His behaviour took about 10 seconds and then the beetles parted in opposite directions (suggesting that both were dead; they were not collected to find out).

The movement of chained pairs over the surface of the increment lasted 30 seconds on average, at most around two minutes, regardless of whether the chained pair emerged from beneath the crust or otherwise they formed the chain on the surface of the dung pad during observation. The time and the probable onset of these movements were not determined. The fact that it was observed only 45 minutes after the beginning of work in the locality does not imply, due to its relatively low frequency and short duration (cf. part A1), that the beetles would perform it only after 15-30 h.

The next day (1.5.5) the observations were made in the same locality and in the same increments in which the mating behaviour was observed previously. Two pairs of *A. distinctus* was observed on the surface of the cubes between 9.30 and 11.30 hours. The only individual that emerged on the surface of the cube during this period was observed at 11.30 h. The weather conditions on 1.5.5 were basically comparable with those on 1.5.4, warm and sunny, despite the observations are reported to have been made.

Coupling pairs of *A. distinctus* or those in the same precopulatory position were found neither on 12.5 nor on 13.5.

### 3. Sievakin or Zabel (1990-91), 17.5.1986, about 200-250 m a.s.l.

CIRCUMSTANCES. A pasture at the foot of a conic mountain SW of the mouth of the Zabelskaya Valley, a gentle south-facing slope, sheep droppings. Research made between 12.30 and 17.10 h (the described observation around 15 h). Weather dry and warm, sunny (the same as for a number of previous days). Temperature measured at 12.45 h: air 29 °C, soil 18 °C.

OBSERVATION. A pair of *A. distinctus* in the static chained position was found under a fresh dung (produced on the same day) about 10.00 h. At this time the increment was opened the male was "grasping" the female's abdomen with spread lamellae of his antennal clubs and was trying to mount her. Thereupon he dismounted (obviously having not found a suitable position to assume the precopulatory position) and tried to mount once again. Then, probably due to disturbance, he dismounted and ignored the female thereafter. This sequence of mating behaviour lasted at most 10 seconds (during this attempt at mounting the female the male continuously moved his antennae with spread clubs over her abdomen). There is no reliable evidence showing that he actually touched the female in doing so. The dung pad mentioned contained a total of 9 *A. prodenus*, 4 *A. distinctus* and 1 *A. finetorum*. Another pair of *A. distinctus* in the static chained position was observed in this locality on the same day (see part C 10).

### 4. Sievakin or Somov (1996), 5.5.1987, about 100 m a.s.l.

CIRCUMSTANCES. A pasture at the foot of the Shingir River about 1 km NW of the village Shingir cattle droppings. Warm sunny day and ground the past were the mating behaviour of *A. distinctus* were observed, sampling were made on cattle and sheep faeces between 10.00 and 17.10 h. The observations were made between 15.15 and 17.10 h. Warm and sunny weather lasted throughout the day: temperature readings at 10.10 h: air 22 °C, soil 11 °C.

OBSERVATION. Around 15.15 h, a series of 30-50 fresh cattle dung pads was found, of usual dimensions (see part A2), covered with a thin crust about 1 mm thick. Their inspection revealed almost immediately the movements of pairs of *A. distinctus* over their surface. Thereupon the observation was concentrated in three cattle dung pads brought up to me (about 30x25x3 cm). While I recorded around 150 individuals of *A. distinctus* walking over the surface of these cubes, lots of them hurriedly slipped on their ventral feet into the crust and crawled rapidly over the lip of the cube and also flew away. I observed at least 30 pairs walking in the chained position. But for one exception, the chains were invariant. A single chain of three beetles was observed at 15.15 h. The chains developed on the surface of the cubes when the chained beetles happened to meet, sometimes met subsequently, the number of such cases was not recorded; each time several seconds after one of the partners slipped on the dung the pair emerging from under the crust in the chained position were recorded. All the chains observed developed on the surface of the dung, even though there were cases in which a male would grab a female as soon as the latter emerged from a hole in the crust. Due to the large number of beetles observed moving within a relatively short period of time by wide observation, however, I am unable to state with certainty that most of the chained pairs did emerge from beneath the crust. Hence of the chains

observed moved over the dung pad for more than 20 seconds. Once chained, the pairs mostly crawled under the crust. Several (roughly five) chains 'broke' without joining again, but in a comparable number of cases the male succeeded in grasping the female again.

Photodocumentation was taken during the observation. Fig. 1 shows the usual way in which a male is attached to the distal part of a female's elytra, and the head of the male with spread lamellae of antennal clubs inclined towards the female's elytra. Fig. 2 shows a male sliding off the female's elytra and trying to gain balance by lifting his body and trying to shift his fore legs forward. (The pairs moved with considerable swiftness and their movements were asynchronous, the male responding to the changed direction or rate of the female's movement with some delay. Related to the size of the beetles, the surface over which they moved was rugged, not smooth.) Fig. 3 shows a male about to attach to a female after having slid off her. Fig. 4 shows a pair in the chained position, crossing a "crust" in the crust of a dung pad; the surface of the excrement was very soft and mushy in consistence and the beetles, stuck in it, often rapidly changed their position and rate of their movement, thus causing the chains to "break".

The activity of *A. distinctus* on the surface of excrements was observed until about 16-15 h at which time it ceased (movements of individual beetles and pairs in the chained position). Two solitary pairs, walking in the chained position, were observed as late as 17:00 hours, at the onset of twilight. At that time a pair in the static chained position was found beneath the crust of the dung (see part C7). No pairs were found in the precopulatory position or in copula.

#### 5 Bohemia centre, Lysá nad Labem env. Karlov Estate (5854), 9 xi 990, 180 m a.s.l.

CIRCUMSTANCES: A fenced horse run, natural horse droppings. Sampling made between 13:40 and 15:20 h (the described observation roughly at 14 hours). Half bright, sunny weather (the first day following a week or so of rainy weather), air temperature at 14:40 h 12 °C.

OBSERVATION: On a quite fresh horse dung about 30x30x 5 cm in size (probably produced in the morning of that day), a pair of *A. distinctus* in the chained position was observed walking over the surface of the dung and crawling into a fissure between two doughnut-like parts of the dung pad. A fragmentary observation lasting at most 5 seconds. The inside of the pad was found to contain about 80 *A. distinctus* and 15 *A. prodromus*. No copulations or pairs in the precopulatory position were observed during the work.

#### 6 Same locality 18 iv 1993

CIRCUMSTANCES: Between 1:20 and 1:40 h, five horse dung pads of rough the same age and structure were analysed in the locality. Half bright, fairly warm weather, estimated air temperature around 15 °C. 15 °C measured at 10:30 h at Čerákovice, about 3 km SW of this locality). High humidity. Rain fell the previous night, occasional showers also came in the morning of 8 April.

OBSERVATION: A group of five fairly fresh but considerably disintegrated horse faeces contained about 300 *A. prodromus*, about 200 *A. distinctus*, about 80 *A. granarius* and one *A. flaviventris*. In one of such dung pads, which, however, still maintained its typical "heap of doughnuts" shape, a pair of *A. distinctus* was found crawling beneath the superficial layer (about 5 cm thick) in an already excavated tunnel, the male "examining" the female's abdomen with his outstretched antennae with spread clubs. This process was observed for about five seconds, whereupon the disturbed beetles stopped and failed to form the chained position. In addition, a pair of *A. distinctus* was found there in the precopulatory position (see part C4).

### B. Mating behaviour observed in captivity

The major aim of the observations made on captive beetles was to attempt obtaining a film record showing pairs of *A. distinctus* moving in the chained position. Furthermore, an attempt was to be made to confirm that the beetles are capable of mating in both spring and autumn. Lastly, an attempt was made to find out whether their movements can take place over the surface of excrements other than cattle droppings.

#### 1 Observation on 30 iv 1988

MATERIAL: Fifteen male and 31 female *A. distinctus* from Lysá nad Labem - Karlov, were collected from horse excrements about 7 hours before the beginning of the observation. The males were marked with white varnish on their elytra in order to distinguish the sexes during the observations, but the white varnish was soon obliterated as the beetles moved in the faeces.

METHODS: The observations were made out of doors between 15:35 and 16:45 h. The beetles were observed in an open glass cage containing a layer of moderately moist, unfertilized earth about 7 cm deep, taken from beneath grass tufts about 30 minutes before the beginning of the observation. A fresh cattle dung pad (produced on the same day) about

\* Figs. 4 will be found at the end of this issue, Plate 6

30x17x4 cm in size was placed on the layer of earth so that it did not cover the whole surface, leaving margins about 5 cm wide. In a later phase of the observation, the dung was lighted by a 60 W bulb from a distance of about 20 cm in order to improve light conditions for the purpose of shooting a film. The sky was overcast throughout the observation.

#### COURSE OF OBSERVATION

15.30 h air temperature 24 °C,

15.35 beetles placed on excrement. Three of them flew away immediately, the remaining ones crawled under the crust of the dung, occasional individuals walking over the dung pad and crawling into it again.

16.00 air temperature 22 °C,

16.00 one pair in chained position seen moving for some 10 seconds, then the beetles were halted (to prepare the camera) but when released again they failed to form the chain anew.

16.12 a chain of two beetles observed for about 90 seconds (and several seconds recorded on film); then the beetles crawled into a pit in the skinny crust previously made by a beetle entering the dung. In that place they stayed about 5 mm deep below the opening (so that their abdomens were visible) and were found there in the complete precopulatory position at 16.16 h. Then they were separately removed from the inside onto the surface of the dung and the male was "mounted" on the female. Thereupon the beetles moved in the chained position for about 10 seconds (several seconds recorded on film) and then the male (probably under the influence of stress) abandoned the female and no more mating behaviour occurred.

16.21 lamp turned on, 16.25 air temperature 25 °C

16.25 to 16.45 lamp turned on, temperature at 16.40 27 °C, no beetles appeared on the surface of the dung, observation ended at 16.45

#### 2. Observation on 23 x 1988

**MATERIAL.** Forty-five beetles (sex undetermined), same locality and kind of excrement as in the preceding experiment, the beetles collected about 6 hours before the beginning of observation.

**METHODS.** The observation was made between 15.45 and 17.10 hours in a room with windows letting in daylight, and under additional lighting with a 60 W bulb from the height of about 30 cm throughout the period. The beetles were observed in an open glass cage containing a layer of dry earth about 1.0 cm deep, on which was placed a fresh horse dung pad formed so as to resemble a cake about 25 cm across and 5 cm thick, not covering the whole area of the bottom (margins at least 10 cm wide).

#### COURSE OF OBSERVATION

15.45 h beetles released and air temperature recorded 22 °C,

around 16.00 two chains of two beetles observed for about 15 seconds and then crawled in chained position into the dung.

16.07 a chain of two observed for about 30 seconds, then crawled into the dung in the chained position,

16.40 one pair in the chained position observed moving for about 10.15 seconds (about 5 seconds recorded on film) whereupon the chain "broke" and the beetles parted.

16.50 air temperature reading 27 °C,

16.55 a pair moving in chained position observed for about 20 seconds. In that position the beetles crawled into the dung.

17.05 a chain of two observed moving for about 20 seconds (about 12 seconds recorded on film), then crawled into the dung.

17.10 observation ended

### C. Further observations of the mating behaviour

This part describes findings of pairs of *A. distinctus*, in which the course of mating behaviour was not observed. The beetles were found in a static position and either stayed in it or responded to the disturbance by fleeing. The records are arranged according to seasonal chronology regardless of the years.

1. Lyck and Labem, race-course (5854), 18 in 1990, about 180 m a.s.l.

**CIRCUMSTANCES.** A sandy training course, flatland, horse droppings. Collections in this locality were made between 15.40 and 17.10 h, the described observation around 16.00 h. Sunny weather, already heating for several days), a fresh breeze. Temperature measured at 15.30 h air 23 °C soil 18 °C.

**OBSERVATION.** Two pairs of *A. distinctus* in complete precopulatory position were found inside a fresh dung pad (produced in the morning of the same or in the evening of the previous day), drawn-up on the surface, about 20x15x5 cm in size. When disturbed, they moved for several (less than 10) seconds one behind the other (a suggestion of behav-

prior to assuming the chained position). The pairs then parted, however, when other disturbed beetles began moving over the densely occupied dung, which contained about 50 *A. prodromus*, about 40 *A. distinctus* and 4 *A. fimetarius*.

2 Bohemia or. Kladruhy nad Labem (5958), 8 iv 1988, about 190 m a.s.l.

CIRCUMSTANCES: A broad woodland ride used in horse training, flatland, horse droppings. Sampling made between 9:30 and 14:00 h, the described observation around 11 h. Slightly hazy and warm weather. Temperature not measured.

OBSERVATION: A pair of *A. distinctus* observed copulating on top of one of about five "doughnuts" lying close to one another but not touching. Inside that doughnut, on the surface of which no more beetles were present, there was only one individual of *A. distinctus*.

3 Lysá nad Labem, race-course (5854), 14 iv 1990.

CIRCUMSTANCES: Observations made in horse droppings between 15:30 and 17:00 h, the described observation around 16:30 h. This was the second sunny and warm day following a period of at least a week of cold weather with nightly frosts. Temperature measured at 15:45 h: air 24 °C, soil 12 °C.

OBSERVATION: A pair of *A. distinctus* in incomplete precopulatory position was found inside a fresh dung pad with dried-up surface, about 40x40x10 cm in size. In all, this dung contained 93 *A. prodromus*, 34 *A. distinctus*, 15 *A. granarius*, 8 *A. fimetarius*, one *A. subterraneus*, 8 *Onthophagus cf. ovatus*, 3 *O. fracticornis* and one *O. similis*.

4 Lysá nad Labem env. Karlov Estate (5854), 18 iv 1993.

CIRCUMSTANCES: as in part A6.

OBSERVATION: A pair of *A. distinctus* was found in incomplete precopulatory position inside a horse dung pad.

5 Bohemia mor. Rará (5548), 29 ix 1985, about 350 m a.s.l.

CIRCUMSTANCES: A pasture on the slope of the Rand Hill, predominantly NW-facing, rugged terrain, sheep droppings. Research made between 8:30 and 13:50 h, the described observation roughly between 9:30 and 10:00 h. Sunny weather, light breeze. Air temperature measured at 8:30: 14 °C and at 12:45: 28 °C.

OBSERVATION: A copulating pair of *A. distinctus* found inside a "medium old" dropping (with a thick crust and fairly supple inside), about 12x8x5 cm in size. In all, the dung contained about 25 *A. distinctus*, 3 *A. fimetarius* and one *A. prodromus*.

6 Slovakia mor. centr., Šúnce (7785), 29 ix 1990, about 250 m a.s.l.

CIRCUMSTANCES: A pasture on a hill directly above the village, collections made in a relatively shallow, dish-like valley slanting towards SW, its slopes facing SE. SW and NW rugged relief, sheep droppings. Observations made between 12:30 and 15:00 h, the described observation between 13:00 and 13:30 h. Sunny and hot weather, air temperature measured at 13:00 h: 31 °C in the sun and 22 °C in shade.

OBSERVATION: A pair of *A. distinctus* in complete precopulatory position found inside a fresh dung (of unrecorded size). The occupation of this dung by beetles was not recorded. The summary record on the sample made in some 15 droppings inspected in the period stated above (and including the record on the observation described), the faeces contained about 60 *Onthophagus cf. ovatus*, about 15 *O. fracticornis*, about 50 *A. prodromus*, about 40 *A. distinctus*, about 40 *A. fimetarius*, one *A. strabus* and one *A. rufus*.

7 Samotor (7696), 5 x 1987.

CIRCUMSTANCES and description of observation as in part A4. A pair of *A. distinctus* in static chain position was found inside a fresh cattle dung pad around 17:00 h.

8 Slovakia mor. or., Jesenské (76-7786), 5 x 1988, about 180-200 m a.s.l.

CIRCUMSTANCES: A pasture at the periphery of the village, at the foot of the projections of the Cerová vrchovina Hills, rugged relief, sheep droppings. Research made between 12:20 and about 17:00 h, the described observation around 13:00 h. Overcast, warm. Temperature measured at 12:30 h: air 23 °C, soil 18 °C.

OBSERVATION: A copulating pair of *A. distinctus* found inside a fresh dung about 5x4x3 cm in size. Besides, this dung contained 8 *A. prodromus* and 3 *A. distinctus*.

9 Kuchyňa (7568-69), 12 x 1985.

For circumstances and description of the observation, see part A1. Around 10:00 h, a pair of *A. distinctus* in complete precopulatory position was found inside an dung pad about 15x15x4 cm in size. This dung contained only about 30 *A. distinctus* but no other coprophagous Scarabaeoidea.

0 Záhřeb (7190-9), 17.x.1986

For circumstances of this finding, see part A3.

OBSERVATION. A pair of *A. distinctus* in static chained position was found inside a fresh (that day's) faeces about 6x3x3 cm in size. The dung contained a total of about 10 *A. prodromus*, 5 *A. distinctus* and one *A. fimetarius*.

11 Bohemia centr., Kostomlaty nad Labem-Lány (5855), 21.x.1990, about 85 m a.s.l.

CIRCUMSTANCES. Extensive horse runs at the outskirts of the village, grassy flatland, horse droppings. Observations made in this locality between 14.00 and 15.00 h, the described observation around 14.30 to 14.40 h. Cloudy, overcast, occasional short periods of sunshine; the cloudy and rainy weather prevailed for about five previous days. Air temperature (under cloudy skies) measured at 14.00 h: 11 °C.

OBSERVATION. A pair of *A. distinctus* in copula and another pair in static chained position found inside a fresh but already disintegrating large heap of "doughnuts" (dimensions not recorded). The number of beetles found in this excrement was not recorded; the summary record for two such heaps (including the one mentioned plus another of much the same size and age) reports about 200 *A. distinctus*, about 150 *A. prodromus* and one *A. fimetarius*.

12, Kladrby nad Labem (5958), 8.xi.1986.

CIRCUMSTANCES. Extensive grassy horse runs around the village, flatland, horse droppings. Research made between 9.20 and 15.20 h. The time of observation was not recorded but it was definitely during early afternoon hours. The findings were recorded by individual excrements, this is the 22nd of 37 records. Sunny weather following a nighty frost (puddles of water covered with a sheet of ice). The records show only the soil temperature of 7 °C measured at 12.30 h.

OBSERVATION. Two pairs of *A. distinctus*, both in copula, were found inside a fresh heap of "doughnuts" about 40x40x10 cm in size. The dung pad contained a total of 15 *A. distinctus* and 4 *A. prodromus*.

#### D. Observation of the mating behaviour outside excrements

1 Moravia mer., Lednice - Nový Dvůr (7266), 13.x.1989, about 180 m a.s.l., D. Král observ.

CIRCUMSTANCES. Extensive grassy horse runs, flatland, horse droppings. Observation made between 13 and 15 h.

OBSERVATION. A pair of *A. distinctus* in copula on a grass straw.

### DISCUSSION

#### 1. On the question of whether the mating behaviour of *A. distinctus* on the surface of dung pads is an exceptional phenomenon among the Central European members of the genus *Aphodius*

Owing to the lack of useful published data, this discussion is based on my own observations. In 1985 to 1993 I found, in many localities in Bohemia, Moravia and Slovakia, about 120 000 specimens of coprophagous Scarabaeoidea, over a half of which were representatives of the genus *Aphodius*. During my research, I recorded all observations of their mating behaviour.

In the following, I do not consider those species whose mating behaviour could not be observed in the field during daylight hours (no observations were made during dark hours), i.e. species whose main period of occurrence and reproductive activity (as confirmed by rearings) fall on late spring and summer. Most probably, these species are on the wing and invade droppings chiefly at dusk and at night. Their movements over the surface of dung would be impossible on open pastures under sunny weather as they would be more or less immobilized by high air temperatures (commonly reaching over 40 °C in sunlit places, as revealed by tentative measurements) (see also Landin 1961: 78-114). This pertains to the following species (I mention here only those species of which I observed hundreds to thousands of individuals): *A. erraticus*, *A. scrutator*, *A. subterraneus*, *A. fossor*, *A. haemorrhoidalis*, *A. immundus*, *A. lugens*, *A. rufus*, *A. sordidus* and partly also *A. rufipes*.

Nor are largely or partly woodland-inhabiting species considered in this discussion. On the one hand, I did not find these species in woodlands in droppings suitable for observations of



mating behaviour on their surface (due to their shape, consistency or size - see part 4 of the Discussion). On the other hand, in the woodland the beetles were found, but for rare exceptions in individual dung pads scattered over rather large areas, which fact prevented me from observing larger concentrations of *Aphodius* spp. in one place, such as in pastures. This pertains to *A. depressus*, *A. sticticus*, *A. ater* and partly also *A. rufipes*, and also *A. brevis*, *A. maculatus*, *A. zenkeri*, *A. nemoralis*, *A. piceus*, *A. uliginosus* and *A. corvinus*, of which species only small numbers (50-200 specimens) were found.

This consideration pertains to species inhabiting open pastures and occurring exclusively or almost exclusively (*A. luridus*, *A. biguttatus*, *A. paracoenosus*, *A. pusillus*, *A. quadriguttatus*) or largely (*A. varians*, *A. granarius*) in spring, or in spring and autumn (*A. distinctus*, *A. prodromus*, *A. paykulli*) or exclusively in autumn (*A. conspurcatus*, *A. serotinus*, *A. thermicola*) in my samples. One might also consider *A. ictericus* - the only individuals from which I succeeded in rearing larvae during autumn were collected in late September (I found adults from June until October). The consideration also includes *A. fimetarius* whose reproduction periodicity has not been completely clarified (cf. Christensen & Dobson 1977, Schmidt 1935: 348-350). In my findings, this species is represented from spring until autumn (in all, I have observed over 10 000 individuals), even if with a maximum in summer.

Other predominantly spring (*A. satellitus*, *A. scrofa*, *A. coenosus* and *A. meridarius*), spring-and-autumn (*A. pictus*, *A. conspurcatus*, *A. reyi*, *A. sphacelatus*) and autumn (*A. obliteratus* and *A. contaminatus*) species have been found only rarely and singly.

I have observed the mating behaviour on the surface of dung pads solely in *A. distinctus*. As far as the mating behaviour was observed in the remaining species, this pertained exclusively to findings of pairs in copula or in complete or incomplete static precopulatory position inside the dung. In the case of the most numerous species, *A. prodromus* (in all about 15 000 specimens observed) and *A. luridus* (about 10 000 specimens observed, the same as *A. distinctus*, which I have frequently observed alighting on fresh excrementa (including cattle dung pads) together with *A. distinctus* (and observing the mating behaviour of all three species), the prevalence of mating behaviour on the surface of droppings can be considered rather improbable. To a certain extent (with respect to many numerous findings in spring and autumn), this can be concluded even for *A. fimetarius*. A similar assumption can also be made for *A. pusillus*, *A. varians* and *A. granarius* (over 1 000 specimens observed), *A. biguttatus* and *A. conspurcatus* (over 500 specimens observed) and *A. paracoenosus* (over 200 specimens determined in my samples).

In the case of *A. quadriguttatus*, *A. paykulli*, *A. serotinus* and *A. thermicola*, the negative findings should be considered quite non-significant owing to the scant material observed (less than 200 specimens). The more can no opinion be offered regarding the species of the subgenus *Nimbus* (*A. contaminatus* and *A. obliteratus*).

From the improbability of mating behaviour on the surface of excrementa in *A. prodromus*, the same can be expected to occur in the related species, *A. reyi* and *A. sphacelatus*. Analogically to a limited extent (a far smaller number of specimens of *A. paracoenosus* observed), this is also true of *A. coenosus*.

Thus, one can state with some reserve that the occurrence of such mating behaviour on the surface of droppings as described here in *A. distinctus* is improbable for the subgenus *Melinopterus* (excluding *A. circumcinctus* see Dellacasa 1983), *A. luridus* and perhaps the subgenus *Euomdatus* (sensu Dellacasa 1983), i.e. for *A. paracoenosus* and *A. coenosus*. On the basis of available data, however, I am unable to hypothesize whether or not other *Aphodius* species than *A. distinctus* behave in this way.

Note: A concentration of a rather large number of individuals of *A. biguttatus* was observed, in a large majority of cases, inside disintegrated sheep faeces covered with a thick and hard crust. Where the small sized spring species (of the subgenera *Phalacrognathus*, *Trichonotulus* and *Erymus*), with metamorphosis from egg to pupa lasting less than a month (confirmed by my own rearings for *Phalacrognathus* and *Trichonotulus*) can find suitable conditions for copulation and oviposition besides in older and hardened dung pads already abandoned by other species, without being exposed to unduly heavy competition with larger species, is an interesting problem.

## 2. On the reconstruction of the course of mating behaviour in *A. distinctus* and on the term "precopulatory position"

I have failed to observe the entire course of the mating behaviour of *A. distinctus* from finding a female up to copulation. However, it can be reconstructed from individual partial observations.

Having found a female, the male seizes her and then their movement follows in the chained position. In finding the female, olfaction apparently plays the major part - see observations of males examining females with spread lamellae of antennal clubs on which olfactory sensillae are concentrated (Meincke 1975). The female in acceptable condition releases a pheromone, thus becoming attractive for males. The finding of a female is probably impeded by the presence of numerous traces of the sexual attractant released on one and the same dung pad by additional females, and possibly even by the smell of the fresh faeces. I suppose that the females are located at short distances and that olfactory examination upon meeting is necessary.

Having spent some time moving in the chained position, the pair halts in a subjectively and objectively suitable place (the partners being sufficiently stimulated to switch to the next phase of the mating behaviour and the selected place warranting its relatively undisturbed course). There they assume first the incomplete and then the complete precopulatory position, whereupon copulation takes place. The fact that copulation does not take place immediately after the movement in the chained position has ended is unambiguously indicated by observations of captive beetles (see Observations, part B1) and is also suggested, to some extent, by observations in the field (see Observations, part A3, and findings of pairs in incomplete precopulatory position, described in Part C). I assume that tactile stimulation is also necessary after the end of movement in the chained position for the copulation to take place. While this may be an innate etho-physiological process, one should also consider that in selecting the suitable place for copulation, the pair is very often affected by disturbing external influences such as encounters with other beetles and making way through narrow spaces.

Locating the female and movement in the chained position can take place inside as well as on the surface of the dung; the precopulatory position is assumed and copulation is performed, apparently obligatorily, inside the dung pad. However, two observations (see Observations, parts C2 and D1) suggest that the reality may be more complicated. In the first case the beetles copulated on the surface of the dung, which fact I am still unable to interpret in a plausible way. The other case - copulation on a grass straw next to an excrement - can be explained thus: from about ten dung pads about as old as the one next to which the copulating pair was found in the locality, over 1 000 individuals of *A. distinctus* were washed out (J. Král pers. comm.). Thus, I may assume that the invasion of the excrements by the beetles resulted in such a degree of competition that some of the individuals capable of copulation were "edged out" to perform mating behaviour in the vicinity of the excrements.

NOTE. In this text I have employed the term "precopulatory" position without any proof that this was actually the case, as I lack any observations of a "postcopulatory" position or of any behaviour following the end of the copulation. Thus, wherever the precopulatory position is mentioned in part C of the Observations, one cannot exclude that a 'postcopulatory' position was involved. However, basing on direct observation of the complete precopulatory position (Observations, part B1) and on the rather unequivocal indication of two additional observations (parts A3 and C1) I believe that my description of the precopulatory positions is right. Thus, the reports in part C on beetles observed in precopulatory positions are not objectively correct but schematized, yet nevertheless possible.

### 3. On the "ritual" nature of movements in the chained position

I observed the beetles moving in the chained position continuously only on the surface of droppings, whereas my observations inside them are only fragmentary or mere suggestions of such movements. However, I believe that this movement is an obligatory part of the mating behaviour of *A. distactus*, a "ritual" whose performance is inevitable for copulation to take place. This assumption is based on the following reasons:

The movement in the chained position has a relatively long duration (at least tens of seconds) and the basic position of the beetles performing it is invariably the same (the male grasping the female with his fore legs at the distal third of the margin of the female's elytra). When walking in this position, the male moves the spread lamellae of his antennal club and most probably touches the female with his antennae, bowed head and the terminalia on its lower surface as well as with the distal margin of his clypeus (due to the small size of the dung beetles observed, I have not observed direct contacts with certainty). I believe that such tactile perceptions (together with those caused by the male's fore legs, stimulate the course of the mating behaviour (i.e., roughly speaking, cause the female to head towards a suitable place, halt in it and become receptive for the end phase of the mating behaviour that immediately leads to copulation) and probably also the essential physiological changes (maturation of spermatozoa, changes in the lumina of female ducts facilitating the reception of sperm, etc.). Besides, as regards contacts with legs, these perceptions increase in the course of the mating behaviour (from one pair of legs during the movement in the chained position up to all three pairs in the static complete precopulatory position).

Considering the conformity of the basic traits of the ecology of most *Aphodius* spp. in the Temperate Zone (non-nesting coprophagous beetles), I assume that the movement in the chained position is obligatory in the pattern of the mating behaviour of the considerable part of members of this genus.

Finally, one may assume (in view of the observations of "multiple" and "branched" chains of beetles) that the movement in the chained position also acts as an intraspecific selection mechanism. In this connection it is necessary to emphasize the fact that males joining a "multiple" chain from its side tried to "break" it, whereas those joining it at its end merely "assumed" their position. However, the scarce data available do not permit any detailed evaluation of this phenomenon.

NOTE. The discussion pertaining to the physiological changes is mere speculation which, however, cannot be omitted, as it is also valid for the subsequent phase when the beetles are in the precopulatory position.

#### 4. On the conditions under which the movements of *A. distinctus* in the chained position take place on the surface of droppings

In the field dung beetles moving over the surface of droppings in the chained position were found exclusively on fresh cattle dung pads (estimated at most one day old). Such excrements show specific structure: at first a pad is a mass uniformly mushy or doughy in consistence which enables the beetles to penetrate under its surface from above. Later, the drying excrement develops a thin slummy crust on its surface, first (in warm and dry weather within less than one hour) at the upper periphery (or in upper projections if the excrement is not cake-like in shape) and then gradually over that part of its surface which is in direct contact with air. At the same time the crust separates (again, first at the upper periphery or projections) from the remaining mass, giving rise to fissures into which the beetles can invade the interior of the dung. I have never observed *A. distinctus* attacking fresh dung pads from below: wherever I did them beneath the cattle droppings this was invariably at their periphery, and the beetles were never found in any of the phases of mating behaviour.

I have observed the mating behaviour of *A. distinctus* in such fresh cattle dung pads on which the crust had not yet developed or was still very thin. Such timing enables the beetles to perform continuous mating behaviour: the formed pairs can invade newly developed fissures at the time when they are still unoccupied by individuals of other species or by old individuals of *A. distinctus*. I assume that the absence of the 'fissure' niche was one of the causes of abundant formation of multiple and branched chains on cattle droppings with still undeveloped crust (see Observations, part A1). This, too, may have been the cause of the considerably longer duration of movements in the chained position (cf. Observations, parts A2 and A4): the beetles "had to wait until they could find a suitable place in which to finish this phase" and, at the same time, they "could be sure that no one would occupy the developing niche before them".

On the basis of the observations described above, it can be stated that the first phase of the mating behaviour (seeking a partner and movement in the chained position) takes place on the surface of cattle droppings for the obvious reason that it cannot take place elsewhere: the consistence of the excrement does not permit movements inside it. Another co-ordinated factor is the fact that it is only the cattle "cakes" that provide on their surface a sufficiently large, even and flat area which (contrary to horse and sheep droppings) permits such movements. My fragmentary observation of a pair moving in the chained position on the surface of a horse dung, see Observations, part A5, is thought to be one of a pair passing from one fissure between the "doughnuts" into another.)

In my opinion, the consistence, shape and size of the upper part of droppings is decisive of the occurrence of mating behaviour of *A. distinctus* on their surface, the consistence being the major factor. This conclusion is also supported by the results of observations of captive beetles in which they moved in the chained position over the surface of an artificially flattened, depressed and smoothed horse dung (see Observations, part B2) so that its shape and consistence resembled that of a cattle cake.

NOTE: I have only succeeded in observing fragments of the mating behaviour inside excrements. Although insufficient, these observations suggest that in the case of horse and sheep droppings all precopulatory and copulatory phases of the mating behaviour of *A. distinctus* take place inside the dung. Most probably, their movements in the chained position take place in corridors, cavities and fissures produced by insects or having developed without their participation (e.g., fissures in a heap of horse "doughnuts"). The consistence of such excrements is considerably higher

compared to that of cattle dung pads. Moreover, the structure of horse excrements is fibrous permitting the movements of beetles even inside a quite fresh dung.

#### 5. On conditions under which the mating behaviour of *A. distinctus* takes place and on the reproduction strategy of the species

I have mostly observed the mating behaviour of *A. distinctus* inside densely populated dung pads, abundantly infested with Staphylinidae and Histeridae, or on unprotected surface of cattle droppings. I assume the following reproduction strategy in *A. distinctus* (and probably numerous other *Aphodius* spp.) as regards fertilization of females: for mating, the beetles seek such conditions that warrant the occurrence of a large number of individuals capable of copulation at one time and in one place, the risk of considerable losses due to predation is ignored; contrary to the nesting Scarabaeidae, these dung beetles do not make use of mechanism minimizing this risk.

Within a certain temperature range, the onset of the mating behaviour of *A. distinctus* does not require any special climatic conditions. I have observed this behaviour at temperatures common in the respective seasons of the year, in different types of weather and at different times of the day. The limiting factors may probably include the physiological condition of gonads and a certain lower temperature limit lying somewhere below 11 °C (see Observations, part C1.).

#### 6. On the question of linkage between copulation and oviposition in *A. distinctus*

I have not observed ovipositing females of *A. distinctus* in nature. Hence, I cannot offer any substantiated opinion on whether the females oviposit, with a certain delay after copulation, into the dung pad in which copulation had taken place, or whether oviposition is temporally and spatially divided from copulation, or whether the females combine the two alternatives. Omitting for the time the question of whether *A. distinctus* produces one or two generations annually, i.e. among other things, whether the females oviposit in autumn and spring or only in spring, it is clear that, at least in spring, oviposition must follow shortly after copulation.

Landin (1961: 195) states, without any further particulars, that, as an exception among the *Aphodius* spp. studied by him, the larvae of *A. distinctus* develop in decaying plant remains. In my findings, *A. distinctus* is the most numerous species together with *A. prodromus* and *A. luridus* in the spring aspect, and with *A. prodromus* in the autumn aspect. Besides, I have repeatedly reared this species successfully in sheep excrements. I have invariably found first to third instar larvae in an excrement and, thus, *A. distinctus* is a non-nesting species. Therefore I consider *A. distinctus*, under the conditions of Central Europe, an obligatorily coprophagous species in both the larval and adult stage (of course, with a wide ecological tolerance, permitting saprophagy if need be).

Hence, the females need for oviposition a certain part of a dung pad, which is not immediately exposed to the risk of being destroyed by the competing adult coprophagous beetles, nor is it open to predators. This part of the dung must be aerated and show consistence suitable for larval feeding. The first condition can hardly be fulfilled by horse and sheep droppings for much of the spring and autumn season. Due to their being easily permeable or due to their small dimensions, these excrements are occupied within several hours or at most 2-3 days, by a large number of adult coprophagous beetles and their predators. Such excrements are depreciated for the larvae within a short period of time: the horse ones by being eaten apart and subsequently lose their shape and inner humidity, the heap of "doughnuts" becoming a flat heap of crushed

matter; the sheep ones, by being completely eaten upon the inside, only the more or less hardened crust remaining. A certain opportunity occurs in early spring (until about the end of the first part of April) and later in autumn (about mid-October and onwards) when a spell of cold weather sets in and lasts for several days. Thus, the invasion of dung pads by insect in those periods may not be as heavy as to act as a factor limiting oviposition. Moreover under such conditions (rather low temperatures, considerable air humidity) there is real possibility that the droppings will keep their consistence and shape for several (2-3) weeks so that larval development can proceed in them until the third instar. In autumn in particular, this may hold true even for larger sheep excrements.

A somewhat more favourable situation is found in cattle droppings owing to their more compact structure and sufficient size. Due to being less readily accessible to air on its inside, a cattle dung is usually invaded successively, fairly large parts of its inside remaining intact for rather long periods of time. Thus, it may be admitted, especially in the case of pads showing dryish not mushy consistence that both copulation and oviposition can take place in one and the same dung pad.

I am inclined to hypothesize that the females can combine the two alternatives (one should also consider the existence of droppings lying in shaded places where their "viability" is longer and which are "less attractive" for the adult beetles). I assume, however, that copulation taking place in one and the same dung pad is exceptional rather than regular. Considering the conditions under which copulation takes place in *A. distinctus* (see the previous part of the Discussion), I believe that in this species, copulation and oviposition are separated in space and time as a rule, at least because the females cannot find suitable places in which to oviposit in the pad in which they had been fertilized. And this assumption is to apply to other non-neating coprophagous *Aphodius* spp. with similar bionomics as well.

#### 7. On the number of generations in *A. distinctus*

Landin (1961: 212) states that in southern Sweden, *A. distinctus* produces two generations annually and that adults hibernates. In their material collected in October, Christensen & Dobson (1976) found no females with developed oocytes, on the contrary, females kept in outdoor iron cages from autumn until spring were found pregnant in spring. The authors conclude from this fact that under the local conditions (Indiana, U.S.A.), *A. distinctus* produces only one generation annually which is quite possible in regard of the continental character of the local climate. However, no fresh excrements were available to their caged beetles so that the results of their experiment should be taken with reserve.

Under natural conditions, I have observed copulating *A. distinctus* both in autumn and in spring. However, one cannot state with certainty that in Central Europe the species produces two generations annually. The condition of the ovaries of beetles found copulating in autumn is unknown and thus no opinion can be offered on whether the sperm could be retained in the receptaculum seminis and fertilization delayed.

No data are available on the condition of gonads of a larger number of females. Only the presence of spent females in samples made in autumn and among those emerged in spring could confirm that oviposition takes place twice within one year. There are three possible ways to demonstrate that at least some of the females collected in spring also emerged in that season: first, by findings of pupae or immature adults in pupal chambers, second, by findings of mature third instar larvae beneath last year's dung pads, both at the very beginning of spring activity of adults at the latest, third, by finding, among pregnant or spent females sampled in spring, two markedly differently "worn" groups by examining their clypei, tibiae and tarsi.

In the case that oviposition and larval development does actually occur in autumn, the "spring" generation is probably "mixed". Adults that are on wing as early as during the first warm early spring period can hardly have not emerged from the pupae or pupal chambers in autumn. The adults of the "actual" spring generation would then follow with some delay due to the necessity of a sufficiently deep layer of soil being warmed over a certain limit before the adults can ("pupate") emerge, apparently during April at the latest.

I do not expect that adults which had already been active in spring could survive until autumn, there being a break in their seasonal occurrence: I have never found them between mid-June and early September (see also Schmidt 1935: 324).

I consider both alternatives - a single generation or two generations (with the spring one "mixed") - to be possible for the Central European populations of *A. distinctus*. The presence of two separate generations is in the highest degree improbable in this region.

### 5. On the observation method

The results presented here are based on extensive observations made in tens of localities selected at random and during several years. In this way I have obtained a rather scarce series of data on the mating behaviour of *A. distinctus*, I have never observed the course of the mating behaviour as a whole. On the other hand, the fact that the observations were made at random contributes to their reliability, may this pertain to the phenomenon of movements in the chained position or to the fact that copulations take place both in spring and in autumn.

Most probably, intensive field observations made in one or a few localities and at short intervals of one or just a few days could provide more numerous and more complete data. However, such observations could be biased by limited variation in external conditions (climate, relief of terrain, exposure of the localities, etc.), particularly if the localities under study should be close to one another. Particular emphasis should be laid on the importance of the terms at which grazing begins and ends. This pertains, first of all, to the entire grazing season which, in many places, is rather short (from about early May until early October). This fact would make it impossible to observe the initial part of the spring and the terminal part of the autumn period of activity of adult *A. distinctus*. Moreover, due to the seasonally limited sources of food, a local population could modify its behaviour (for example, the spring mating cycle could take place outside the pasture under study in another suitable nearby locality, etc.).

The most detailed data could be obtained from laboratory rearings but, in my opinion, their value as a basic information source would be dubious. However precisely arranged, a laboratory experiment cannot simulate the influence of natural conditions in the open space, starting with climatic influences and ending with interspecific competition. It is my opinion that in studies of the course of the mating behaviour of non-nesting coprophagous Scarabaeoidea, observations of the beetles under natural conditions are of decisive importance.

### SUMMARY

1. On the basis of nineteen observations under natural conditions and two observations of captive beetles, the course of the mating behaviour of *A. distinctus* has been reconstructed, starting with the male searching for the female and ending with copulation. The mating behaviour has two phases: viz., a mobile one that includes searching for the partner and movement in the chained position, ending in finding a place suitable for copulation; and a static one including the incomplete and complete precopulatory position and copulation. The first phase either takes place on the surface of dung pad (except for the movement apparently leading directly to the

place selected for copulation), or the whole phase takes place inside a dung, the second phase, but for rare exceptions, takes place inside the dung.

2 The author considers the movement of beetles in the chained position to be an obligatory part of the mating behaviour of *A. distinctus*, which may also act as an intraspecific selection mechanism. In nature, this kind of movement on the surface of droppings has only been observed on cattle dung pads, in captivity also on artificially modified horse dung. Fragmentary observations of this movement have been also made inside horse and sheep droppings. Whether the movement in the chained position takes place on the surface of the dung most probably depends, first of all, on its consistence being impermeable for the beetles, as well as on the presence of a sufficiently large and relatively even area on its surface. Such conditions are offered by fresh cattle dung pads. Movements over their surface enable the pairs of *A. distinctus* immediately to occupy fissures developing beneath their crust.

3 The mating strategy of *A. distinctus* is discussed. Copulations apparently take place if a larger number of individuals capable of copulation are present in one place at one time, there being no developed mechanism protecting the beetles from predators.

4 It is probable that in *A. distinctus*, copulation and oviposition are spatially and temporally separated as a rule. The direct linkage between copulation and oviposition is hindered by the presence of numerous coprophagous and carnivorous insects in the dung in which copulation had taken place, as well as by this dung being debased by the feeding of the adults of the coprophagous insects within a short period of time.

5 The obligatory occurrence of the movement in the chained position in the mating behaviour pattern, the suggested mating strategy and the copulation separated from oviposition are hypothesized to occur even in other non-nesting *Aphodius* spp.

6 The number of generations annually produced by the Central European populations of *A. distinctus* is discussed. The possible alternatives are either a single generation with larval development in spring, or two generations. In the latter case, the spring generation would probably be mixed, consisting of adults emerged in spring and adults that had already been active in previous autumn.

7 Field observations, not laboratory experiments, are considered by the author to be conclusive in studies of the mating behaviour of non-nesting coprophagous Scarabaeoidea.

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**The structure and the development of the ductus and saccus endolymphaticus in  
*Alligator mississippiensis* and *Phrynocephalus versicolor* (Reptilia)**

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**Saccus endolymphaticus, ductus endolymphaticus, calciumcarbonate, dura mater, intradural location, ultrastructure, reptiles**

**Abstract** Structure of the ductus endolymphaticus (DE) and saccus endolymphaticus (SE) was studied in *Alligator mississippiensis* and *Phrynocephalus versicolor*. The development of these structures was investigated in *Alligator mississippiensis*. The ultrastructure of the epithelium lining SE was observed in *Phrynocephalus versicolor*. The SE in the experimental animals was located in the duplication of dura mater. The lumen of the DE and SE was lined by a simple cuboidal or columnar epithelium. A dense content was observed in the lumen of all compartments of the SE and DE in the developmental stages of *Alligator mississippiensis*. In the epithelium lining of the SE of *Phrynocephalus versicolor* cells with microvilli at the apical zone and invaginations of the basal cell membrane were revealed. A basal labyrinth was not discovered. In their cytoplasm light vacuoles and dark granules without a limiting membrane were observed. The lumen of the SEs of *Phrynocephalus versicolor* was free of any electron dense material. A rich capillary network was formed in the subepithelial connective tissue.

**INTRODUCTION**

In our previous studies the morphological structure and embryogenesis of the ductus endolymphaticus (DE) and saccus endolymphaticus (SE) in *Gallus gallus f. domestica* were studied. We also aimed at the study of the comparative morphology in vertebrates (Klika & Zajicová 1988a, 1988b, 1989). In all vertebrates we mostly revealed the DE and SE in the intradural location. In birds, however, an intrarachnoidal location of the SE and DE in close relation to the IV<sup>th</sup> ventricle of the brain was discovered (Klika & Zajicová 1988a, 1988b).

According to Hase (1877) and Whiteside (1922) SE of some reptiles is mostly formed by the two small vesicles located under the suture between the parietale and occipitale. But in *Alligator mississippiensis* Klika & Zajicová (1989) described a uniform single sac. An unusual character of the DE and SE has been described also in many geckos, iguanians, agamids and chamaeleonids (Wiedersheim 1876, Ineich & Gardner 1989, Hauer 1989). Due to all differences so far described, we decided to study the SE in reptiles. The aim of our study was to evaluate the histotopographic relationships of the SE and DE to the neighbouring structures and to observe the formation of SE in the course of the prenatal development in *Alligator mississippiensis*. We also tried to describe the ultrastructure of the SE epithelial lining in agama *Phrynocephalus versicolor*. To our knowledge only light microscopic observation of this structure has been published in reptiles.

## MATERIAL AND METHODS

In our experiments two reptiles species were used: agamid *Phrynocephalus versicolor* (Strauch, 1876) - Squamata (Sauria: Agamidae); crocodilian *Alligator mississippiensis* (Daudin, 1802) - Archosauria: Crocodilia.

The histomorphologic relationship of the DE and SE to the neighbouring structures were studied in ten species of reptiles. In crocodile prenatal development of the DE and SE was examined. Embryos with a head-length 11.6 mm, 11.9 mm, 14.9 mm, 16.8 mm, 17.9 mm, 22.0 mm, 23.0 mm, 33.1 mm were studied. The heads of crocodile embryos were fixed in 10% formaldehyde, dehydrated in ascending ethanol series, and embedded in paraffin. Series of paraffin sections in series were stained with hematoxylin-eosin. The tissue samples taken from the agamid *Phrynocephalus versicolor* were fixed in 2.5 % glutaraldehyde in a 0.1 M cacodylate buffer and postfixed in 1 %  $\text{OsO}_4$  in a 0.1 M cacodylate buffer. After dehydration with an ascending acetone series, the material was embedded in Durcupan ACM. The semithin sections were stained with 0.2 % azure in the combination with 2 % basic fuchsin. Ultrathin sections were prepared on the LKB microtome and were stained with 2% uranylacetate and lead citrate (Reynolds, 1963).

## RESULTS

### *Alligator mississippiensis* (Daudin, 1812)

In smallest embryos (head-length 11.6 mm and 11.9 mm) the cartilaginous sacculoutricular part were observed. The ductus endolymphaticus originated from the sacculus (Fig. 1) as a small projection, that penetrated through the foramen endolymphaticum (Fig. 2) into the connective tissue sheath of the brain. In this stages, the DE was represented by a blind evagination (Fig. 3).

In embryos with head-length 14.9 mm the DE was tubular in shape. The DE arose from the sacculus and ran in a dorsal direction into the connective tissue. In cross section, the DE appeared as two ovoid vesicles. These vesicles lay in the dura mater duplication situated dorsally and caudally in respect to the IV<sup>th</sup> ventricle of the brain (Fig. 4).

In the embryos with head-length 16.8 mm, 17.9 mm and 22.0 mm, the DE was voluminous, penetrated through the foramen endolymphaticum and formed two voluminous structures. In the embryos with the head length 22.0 mm two vesicles with folded walls were observed in the connective tissue.

Prior to incubation (head-length 33.1 mm) the DE formed a narrow tube that arose from a sacculus and ran through the foramen endolymphaticum. The DE increased in diameter and formed a flat vesicle (Fig. 5) that was continuous with the dilated voluminous SE (Fig. 6). In the medial area both compartments fused and formed a common SE situated in the duplication of dura mater (Fig. 7). Then the single sack was divided into two blindly ending sacs (Fig. 8).

The DE and SE were lined with a cuboidal or columnar epithelium. During the development the compartments of the SE and DE were filled with a fine granular material.

### *Phrynocephalus versicolor* (Strauch, 1876)

The SE was attached to the dense connective tissue of the dura mater (Fig. 9) where numerous melanophores were observed. The outer layer of dura mater was continuous with the perosteum of the bone of the skull (Fig. 9). The SE was located in the dura mater in close relationship to the leptomeninges and the walls of the SE were folded. The outer surface of the SE was surrounded with the subepithelial loose connective tissue rich in blood capillaries and the layer of the dense connective tissue of dura mater was observed (Figs 9a, 9b). The epithelial lining was simple cuboidal or columnar (Figs 9a, 9b, 10) with well developed apical junctional complexes and numerous interdigitations (Figs 10-13). The apical portions of the epithelial cells were equipped with short microvilli (Figs 10, 13). In the cytoplasm small rod like mitochondria, short profiles of granular endoplasmic reticulum, and well developed Golgi complex surrounded with small vesicles were observed (Figs 12, 13). The cytoplasm was rich in glycogen particles.

Tight vacuoles with a homogeneous content enclosed by a partly discontinuous membrane together with large groups of small light vesicles were also revealed (Figs 10-12). The vacuoles and vesicles were accumulated mostly in the apical portions of the cells (Figs 12,13). Dark granules were also discovered in the cytoplasm (Fig. 3). The granules were not limited by a membrane but in their vicinity layers of an electron lucent and finely granular material were revealed. The vacuoles did not discharge their content into the lumen of the SE. The SE was free of any electron dense material. The basal surfaces of the epithelial cells had a complicated appearance with many tiny projections. The epithelial cells rested on a well developed basal lamina in which reticular fibers were attached.

## DISCUSSION

We have demonstrated that in *Alligator mississippiensis* and *Phrynocephalus versicolor* the DE and SE were situated in the duplication of the dura mater.

These findings do not correspond to those reported in birds. In adult fowls (*Gallus gallus domesticus*) as well as in their embryos, and in *Passer domesticus* the intracranial location of these structures has been demonstrated (Klika & Zajicová 1988a, 1988b, 1989).

The intracranial location of the SE in our reptiles corresponds to that reported in anuran amphibians and mammals. In frogs (Anura) very complicated structure of the SE was demonstrated. The DE protruded from the sacculi through the foramen endocranium and continued as the voluminous SE. The SE penetrated the vertebral canal to the level of the 7<sup>th</sup> vertebra. Its processes laid upon the spinal ganglia. This complicated organization and development of the DE and SE in *Rana temporaria* was described by Whistler (1977) and later by some other authors (Denpster 1980, Ecker 1984, Birkenmeier 1980, Kawamura 1987, 1988, Klika & Zajicová 1989). In mammals (guinea pig, bat, mouse, rat, cat) the SE was found in the duplication of the dura mater (Lundquist 1965, 1976, Rask-Andersen et al. 1979, 1984, Friberg et al. 1984, 1985, Bayger-Sjohack et al. 1986, 1988, Hultcrantz 1986, Klika & Zajicová 1989). Small differences in the location of the SE were observed in man. The SE was situated in the temporal bone and in the connective tissue of the dura mater (Schindler 1980, 1981). In the Mongolian gerbil, which inhabits semi-desert areas, the SE was discovered in the temporal bone (Barbara et al. 1987, 1988).

Our observation in *Alligator mississippiensis* revealed that the development of the DE and SE was finished before incubation. Its SE was represented by a single sac which arose by means of the fusion of two vesicles. The single sac was described by Klika & Zajicová (1989). But we observed that the single sack divided again into two small blind vesicles. These findings are similar to those presented in some species of reptiles. Hassé (1873) in *Anguis fragilis*, *Lacerta viridis*, *Chelonia mydas*, *Testudo graeca* also described SE composed of two small sacs, but they never fused.

In contrast to our results a different organization of the SE was described in many geckonophorans and chamaeleonids (Wiedersheim 1876, Ineich & Gardner 1989, Bauer 1989). In *Phyllodactylus*, the SE ran to the roof of the brain and left the cranial cavity through the occiput and spread into the musculature of the neck. It ended as a large sac in the pectoral girdle region. In the embryos, as well as in adult individuals, the DE and SE were fixed by lime like substance. The paired SE did not fuse in *Phyllodactylus*. In *Ascalabotes* the paired SE joined in the area of the parietal suture and separated again after they had left the cranial cavity (Wiedersheim 1876). A very interesting report was presented by Ineich & Gardner (1989). In adult females of the gecko *Lepidodactylus lugubris* they observed hypertrophy of the SE in

the reproductive period during the oviductal eggs development. The dilated sacs filled with the lime-like substance were taken for a calcium reservoirs important for the bone growth and for the egg's shell production (Bauer 1989).

In *Alligator mississippiensis* we found the dense material in all compartments of the DE and SE. This material resembled the lime-like substance which was described in many embryos and adult individuals of some vertebrates (Wiedersheim 1876, Hasse 1873, Vasquez 1955, De Vincentis & Marmo 1968, Kawamata 1987, 1988).

In our experimental animals, the lumen of the SE was lined with a simple cuboidal or columnar epithelium. Compared with the birds (Klika & Zajícová 1988a, 1988b) blood vessels were more numerous in the walls of the SE in reptiles. In *Phrynocephalus versicolor* tiny invaginations of the basolateral membrane were revealed, but the typical basolateral labyrinth, that had been described in birds (Klika & Zajícová 1988a, 1988b), was never discovered. In the epithelial cells lining the SE of the agama (*Phrynocephalus versicolor*), light vacuoles and dark granules without a limiting membrane were observed. This type of dark granules has not been described in the SE epithelium in other vertebrates. The proportion of the vacuoles and dark granules, their quantity, size, shape and distribution in the cytoplasm of the epithelial cells, were variable. However, the extrusion of the content of the vacuoles and granules into the lumen of the SE was not encountered. In contrast to crocodile, the lumen of the SE was free of electron-dense substance.

Several types of epithelial cells were described in the epithelium lining of the SE in amphibians, birds, and mammals (Lundquist 1965, 1976; Schundler 1980, 1981; Bagger-Sjoberg & et al 1986; Barbara 1987, 1988; Kawamata 1987; Klika & Zajícová 1988a, 1988b, 1989). In agama (*Phrynocephalus versicolor*) we were not able to confirm this variability.

#### A c k n o w l e d g e m e n t

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IN MEMORIAM PROFESSOR OTA OLIVA  
(with complete bibliography)

Professor Ota Oliva, CSc., an ichthyologist of European renown, a foremost Czech zoologist, the founder of modern Czechoslovak ichthyology, died after a short illness in December 29, 1994.



Born in Prague on December 12, 1926, Oliva completed there his secondary school education. Owing to his deep interest in nature, he matriculated in 1946 at the Charles University, Prague to study natural sciences. As an adolescent, he was greatly interested in aquarium fishes and their breeding; he lectured frequently on this subject and started to publish his experience. At that time, he was greatly influenced by Professor O. V. Hykš. In the first years of his academic life at the Faculty of Sciences, Charles University, he devoted his time partly to studies on the morphology and secondary sexual characters of fishes, partly to faunistic studies. He contributed to a better understanding of the distribution of several fish species in our country: *Alburnoides bipunctatus*, *Cobitis taenia*, *Cottus poecilopus*, *Gobio aubipinnatus*, *G. kessleri* a.o.) and added notes on their first records in the country. The subject of his dissertation thesis was a "Revision of Czechoslovak fishes with reference to their sexual dimorphism". In addition to native fish species, Professor Oliva studied fishes from various other countries such as Poland, Albania, Japan and later Sudan, Iraq and India. Apart from taxonomic studies, he started as early as in the fifties to show interest in various fish populations colonizing pools in the basin of the Labe river. He examined their rate of growth, increase in biomass etc. and published his first papers on the size of fish populations in Czechoslovakia. This became also the topic of his PhD thesis (1958). Later, he focused his attention on large bodies of water, particularly the dam lakes Kličava and Šaupy. In the sixties, being initiated by Professor Bradáč from the Cracow University, he became involved in studies on the anatomy of fishes. He published a

number of papers along these lines, of which his papers on the size of the surface of gills of *Leuresthes* and the myodome of fishes were of particular importance. In 1963, he surveyed in his habilitation paper the results of his studies on the morphology and anatomy of fishes and of his studies on fish populations.

In the seventies and eighties, Professor Oliva's publishing activities were most variegated. On the one hand, he published papers on the morphology of both native and foreign fish species; on the other hand, he remained interested in ecological problems. Several of his papers were written in collaboration with foreign authors.

During his academic years, Professor Oliva published 154 original scientific papers, 152 various communications and short reviews, 10 popularizing articles devoted to aquaristics, 3 reviews of the literature, 104 biographical papers and obituaries, 6 translations, 11 books and text books for university students. His publishing activities reached their peak with the publication of the four-volume "Fauna of the Czech and the Slovak Republic" which he edited and in which he participated with several chapters. Three of the four volumes have been published: Amphibians, Reptiles and Lampreys and Fishes (Part 1).

Professor Oliva was a member of 8 foreign and 9 Czechoslovak (now 9 Czech) scientific societies such as the Canadian Ichthyological Society, Zoological Society London, Herpetological Society London, Polish Zoological Society, Cracow, Indian National Academy of Sciences, Czech Zoological Society and others. He also was a member of several editorial boards of scientific and popular periodicals.

Apart from scientific activities, his time was well occupied by academic work at the Department of Zoology as Chair of Vertebrate Zoology, Faculty of Sciences, Charles University in Prague. He delivered lectures on the zoology

of vertebrates, ichthyology and herpetology, and directed specific practical exercises. He was in charge of a total of 95 theses of which 72 were on ichthyology and 23 on herpetology. He acted as consultant to 6 foreign postgraduates from India, Sri Lanka, the Sudan and Spain (5 PhDs and one Master's degree). All returned to their countries where they are occupying leading positions in research, science and universities.

Owing to his numerous activities, Professor Oliva established a scientific school which contributed greatly to an understanding of fishes as regards their morphology, taxonomy, zoogeography and ecology.

Apart from science, Professor Oliva had many other interests. From his early youth, he was interested in aquarium fishes; between 1948 and 1967, he was Chief Editor of the periodical "Akvarium a terárium" (Aquarium and Terrestrial). His knowledge of fishes colonizing all types of water in our country, which he published in various periodicals and passed on in lectures, was greatly appreciated by the practice. Professor Oliva was most popular among those concerned with the propagation of fishes. Another object were amphibians and reptiles, but he was also greatly attracted by history. He published a number of articles about the history of natural sciences.

He kept up many professional and personal contacts with foremost ichthyologists and, whenever approached, was always willing to help. He was an excellent entertainer with a great sense of humor and never spoiled any fun. He kept up a close friendship particularly with a number of Polish ichthyologists.

Professor Oliva's personality and his contribution to the development of zoology, particularly ichthyology, in post-war Czechoslovakia will be even more appreciated as the years go by. Czech science has lost one of its important representatives, who founded modern Czech ichthyology and, as can be said, an ichthyologist of European importance. He has created with his work a sound foundation for the work of his numerous pupils. May it be an inspiration for the future.

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3 [Aquaristics in Austria]. *Akvaristické Listy* 20: 39-40  
4 [Aquaristics in Finland]. *Akvaristické Listy* 20: 40  
5 Contribution to the systematics of three species of *Cichlasoma*. *Akvariet* 5/6 22: 53-56 (in Engl.)  
6 [The biology of *Amphystoma mexicanum*]. *Akvaristické Listy* 20: 63-64, 75-78.  
7 [Exhibition of aquaria and terraria in Copenhagen]. *Akvaristické Listy* 20: 81-82  
8 [About live-bearers of the families Poeciliidae and Jannynsiidae]. *Akvaristické Listy* 20: 89-98  
9 [Aquaristics in Sweden]. *Akvaristické Listy* 20: 109-110

1949

- 20 [Aquaristics in Poland]. *Akvaristické Listy* 21: 45  
21 [Circle of aquarium-hobbyists in Warsaw, Poland]. *Akvaristické Listy* 21: 75  
22 [About war troubles of Polish aquarium-hobbyists]. *Akvaristické Listy* 21: 35

1950

- 23 Look on American aquaristics]. *Akvaristické Listy* 22: 33-34.  
24 [About self-sufficiency in import of aquarium fishes and terrarium animals]. *Akvaristické Listy* 22: 122-123

1951

- 25 [We are establishing the aquarium]. *Člověk a příroda* 8/9: 134-135  
26 [About systematical position of the mouth-breeder "*Haplochromis moffati*" (Castelnau 1862)]. *Akvaristické Listy* 23: 56-57

1952

- 27 OLIVA O. & LELIAK J. [Electric cell]. *Vestník* 31: 46-48

1956

- 28 [Tropical fishes bred here?]. *Živa* 4: 112-113  
29 [Note on genera *Nannostomus* and *Poecilibrycon*]. *Živa* 4: 232-233

1957

- 30 [Snake-head]. *ABC Mladých Techniků a Přírodovědců* 10: 6  
31 [Aquaristics in USSR]. *Živa* 5: 188  
32 [*Saccobrycon fossilis*]. *Živa* 5: 227

1958

- 13 [About snake-head from the river Amur]. *Aquarien u. Terrarien* 5. 235 (in German).
- 14 [Some notes about progressive tradition of our aquaristics]. *Akvárium a Terárrium* 1. 1-3
- 35 OLIVA O. & ŠAFRÁNEK V. [Our experiences with the breeding of *Tilapia macrocephala*]. *Akvárium a Terárrium* 1. 68-69
- 36 OLIVA O. & ŠAFRÁNEK V. [Some words about lung-fishes]. *Živa* 6. 154
- 37 [Is it prosperous to plant foreign fishes into our waters?]. *Živa* 6. 156
- 38 [About Amur snake-head]. *Živa* 6. 231
- 39 HYKŠ O. & OLIVA O. [Bádky hadík (Ham-Buch)]. *Akvárium a Terárrium* 1. 10.
- 1960
- 40 [Alligator-Gar, *Lepisosteus tristoechus*]. *Akvárium a Terárrium* 4. 54-56
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- 4 [Micropterus interruptus Boulenger, 1889]. *Wzzechswiat* 1. 50 (in Polish).
- 42 [Gastropiceus sternicla Linnaeus, 1758]. *Wzzechswiat* 1. 50 (in Polish).
- 43 [Puntius tetrazona Bleeker (Cyprinidae)]. *Wzzechswiat* 3. 74 (in Polish).
- [Copeina amoldi Regan]. *Wzzechswiat* 3. 74 (in Polish).
- 45 [Rasbora heteromorpha Duncker]. *Wzzechswiat* 4. 98-99 (in Polish).
- [Pterophyllum emelkei Ahl]. *Wzzechswiat* 4. 99 (in Polish).
- 47 [Nannobrycon eques (Steindachner)]. *Wzzechswiat* 5. 123-124 (in Polish).
- 48 [Puntius oligolepis Bleeker]. *Wzzechswiat* 5. 23 (in Polish).
- [Beita splendens Regan]. *Wzzechswiat* 9. 228 (in Polish).
- 49 [Munodycylus argenteus L.]. *Wzzechswiat* 9. 228 (in Polish).
- 50 [Macropodus vari auratus (Lacépède)]. *Wzzechswiat* 9. 227-228 (in Polish).
- 5 [Corydoras paleatus Jenyns]. *Wzzechswiat* 10. 255 (in Polish).
- 52 [Xiphophorus helleri Heckel]. *Wzzechswiat* 10. 255 (in Polish).
- 53 OLIVA O. & ŠAFRÁNEK V. [Triturus vulgans]. *Živa* 9. 77
- 1962
- 54 [Noemacheilus massyae]. *Akvárium a Terárrium* 1. 0
- 55 [Genus Pelmatochromis]. *Akvárium a Terárrium* 1. 1
- 56 [Acquidens latifrons Steindachner]. *Wzzechswiat* 1. 21 (in Polish).
- 57 [Lebistes reticulatus (Peters)]. *Wzzechswiat* 2. 50-51 (in Polish).
- 58 [Corynopoma nusi Gill]. *Wzzechswiat* 2. 50 (in Polish).
- 59 [Aplocheilichthys lineatus (Cuv. et Val.)]. *Wzzechswiat* 4. 106 (in Polish).
- 60 [Heteropneustes fossilis (Blanch. 1792)]. *Wzzechswiat* 4. 106 (in Polish).
- 6 [About swamp-minnow, *Phoxinus phoxinus* in Poland]. *Akvárium a Terárrium* 6. 83-84
- 62 Einige Bemerkungen zum auftreten von *Proteropterus marmoratus* (Pallas) in der Tschechoslowakei. *DATZ* 6. 171
- 63 [About transporting of terrarium animals]. *Akvárium a Terárrium* 5. 32.
- 64 [Phallochorus caudomaculatus (Henckel) var. reticulatus]. *Wzzechswiat* 6. 163 (in Polish).
- 65 [Taurichthys albonubes S. Y. Lin]. *Wzzechswiat* 3. 79 (in Polish).
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- 66 [Foreword to next annual issue of the bimonthly "Akvárium a Terárrium"]. *Akvárium a Terárrium* 7. 1-2
- 67 [Corydoras Schulzei Holý, 1940]. *Wzzechswiat* 6. 146 (in Polish).
- 68 [Cryptopterus bicinctus (Val., 1839)]. *Wzzechswiat* 6. 146 (in Polish).
- 69 [Tetmaterna ladiges Ahl]. *Wzzechswiat* 9. 219 (in Polish).
- 70 [Dania rerio]. *Wzzechswiat* 9. 220 (in Polish).
- 7 [Epiplatys surinensis]. *Wzzechswiat* 10. 243 (in Polish).
- 72 [Cotisa fasciata]. *Wzzechswiat* 10. 243 (in Polish).
- 73 [Pachypanchax homalonotus]. *Wzzechswiat* 11. 259 (in Polish).
- 74 [Monodactylus argenteus]. *Wzzechswiat* 11. 269 (in Polish).
- 75 [Three interesting catfishes]. *Akvárium a Terárrium* 1. 12
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- 76 [Platyistion megacephalum]. *Akvárium a Terárrium* 1. 48
- 77 [About aquarium-hobby in Czechoslovakia]. *Wzzechswiat* 1. 7-9 (in Polish).
- 78 [Epiplatys chapen Sauvage]. *Wzzechswiat* 1. 23 (in Polish).
- 79 [Pachypanchax playfarni Gunth]. *Wzzechswiat* 1. 23 (in Polish).
- 80 [Ctenopoma fasciolarum]. *Wzzechswiat* 4. 9. (in Polish).
- 81 [Prič's legacy to the aquaristics]. *Akvárium a Terárrium* 5/6. 65-66.
- 82 [Leiocassis brashnikovi Berg]. *Wzzechswiat* 2. 47 (in Polish).
- 83 [Lepisosteus tristoechus]. *Wzzechswiat* 2. 47 (in Polish).

84 [*Protopterus dollor* Boulenger, 1900] *Wszeczwiat* 12 275 (in Polish)

1965

85 [*Macropodus vridisauratus concolor* (E. Ahl, 1935)] *Wszeczwiat* 11 288 (in Polish)

86 [*Megalophodus sweglesii*] *Wszeczwiat* 12 313 (in Polish)

87 [*Labes bicolor* (H. M. Smith 1931)] *Wszeczwiat* 5 134 (in Polish)

88 [*Mesogomphus chaetodon* (Baird, 1855)] *Wszeczwiat* 5 134 135 (in Polish)

89 [*Pantus filamentosus* (Valenciennes, 1844)] *Wszeczwiat* 9 232 (in Polish)

90 [*Tetraodon fluviatilis* (Hamilton Buchanan, 1822)] *Wszeczwiat* 7/8 204 (in Polish)

91 [*Pelmatochromis erhensis*] *Wszeczwiat* 1 19 (in Polish)

92 [*Neolebus ansorgei* Bowenger] *Wszeczwiat* 1 50 (in Polish)

93 [*Astronotus ocellatus* Agassiz, 1829] *Wszeczwiat* 3 78 (in Polish)

1968

94 [About fish hatcheries in Florida] *Akwarium a Terrarium* 5 71

95 [Treatment of fishes with hypermangan bath] *Akwarium a Terrarium* 11 89

1969

96 [About discus fish] *Akwarium a Terrarium* 12 39

1974

97 [Several remarks to *Astronotus ocellatus*] *Akwarium a Terrarium* 17 123

1975

98 [*Ichthius nebulosus*] *Akwarium a Terrarium* 17 51

97 [Three spined stickle back] *Akwarium a Terrarium* 18 90 91

1979

98 [About genus *Trichopsis*] *Živa* 27 67

1980

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1984

100 [*Mesogomphus chaetodon*] *Živa* 32 71 73

1985

101 [*Phallostethus dunckeri*] *Živa* 33 226

#### Translations (in Czech)

1947

1 Stiger M. The exposition of aquarium and terrarium in Strasbourg *Akvaristické Listy* 19 33

2 *Discoglossus pictus* *Akvaristické Listy* 19 50-51

1959

3 Skrochowska S. *Salmo trutta* L. and *Salmo trutta* m. fario L. in ponds *Živa* 54 35

1960

4 Suchovajchov F. M. Psarenkova A. S. To the problem of acclimatization of asiatic fishes in Europe *Zool. Listy* 1

1980

5 Bartel R. Rainbow trout in the Baltic sea *Živa* 46 80

1981

6 Andreason S. The life of bullhead (*Cottus gobio*) *Živa* 67 149 150

Miroslav Svátara





Plate I Figs 52-56. Habitus of holotypes of: 52 - *L. richteri* sp. n., 53 - *L. heinz* sp. n., 54 - *L. brancuceli* sp. n., 55 - *L. deuveianus* sp. n., 56 - *L. jani* sp. n.



Plate 2. Figs 57-61. Habitus of holotypes of: 57 - *L. kiarae* sp. n., 58 - *L. kucerai* sp. n., 59 - *L. barkamensis* sp. n., 60 - *L. haeckeli* sp. n., 61 - *L. kalabu* sp. n.

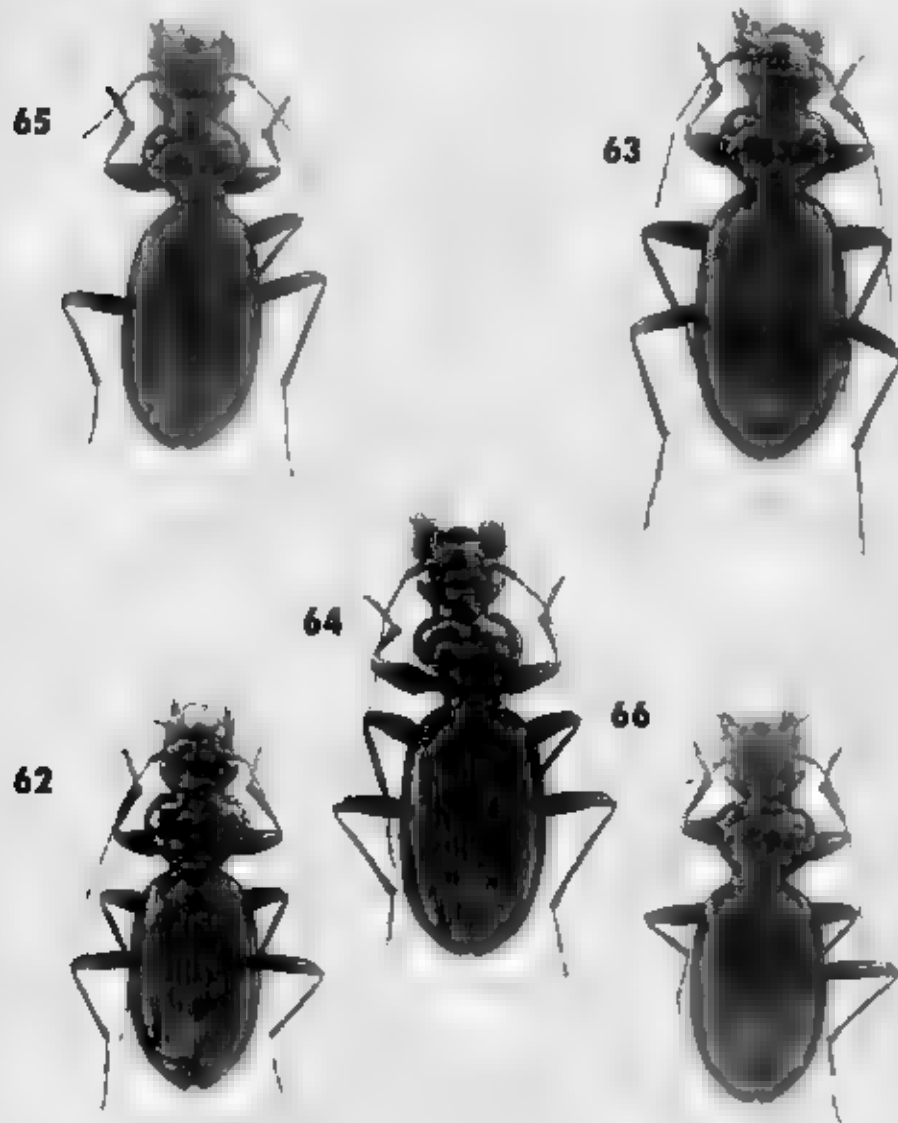


Plate 3 Figs 62-66. Habitus of holotypes of: 62 - *L. kungdingensis* sp. n. 63 - *L. langmuirianus* sp. n. 64 - *L. sciakyi* sp. n. 65 - *L. shuamaluensis* sp. n. 66 - *L. yajiangensis* sp. n.

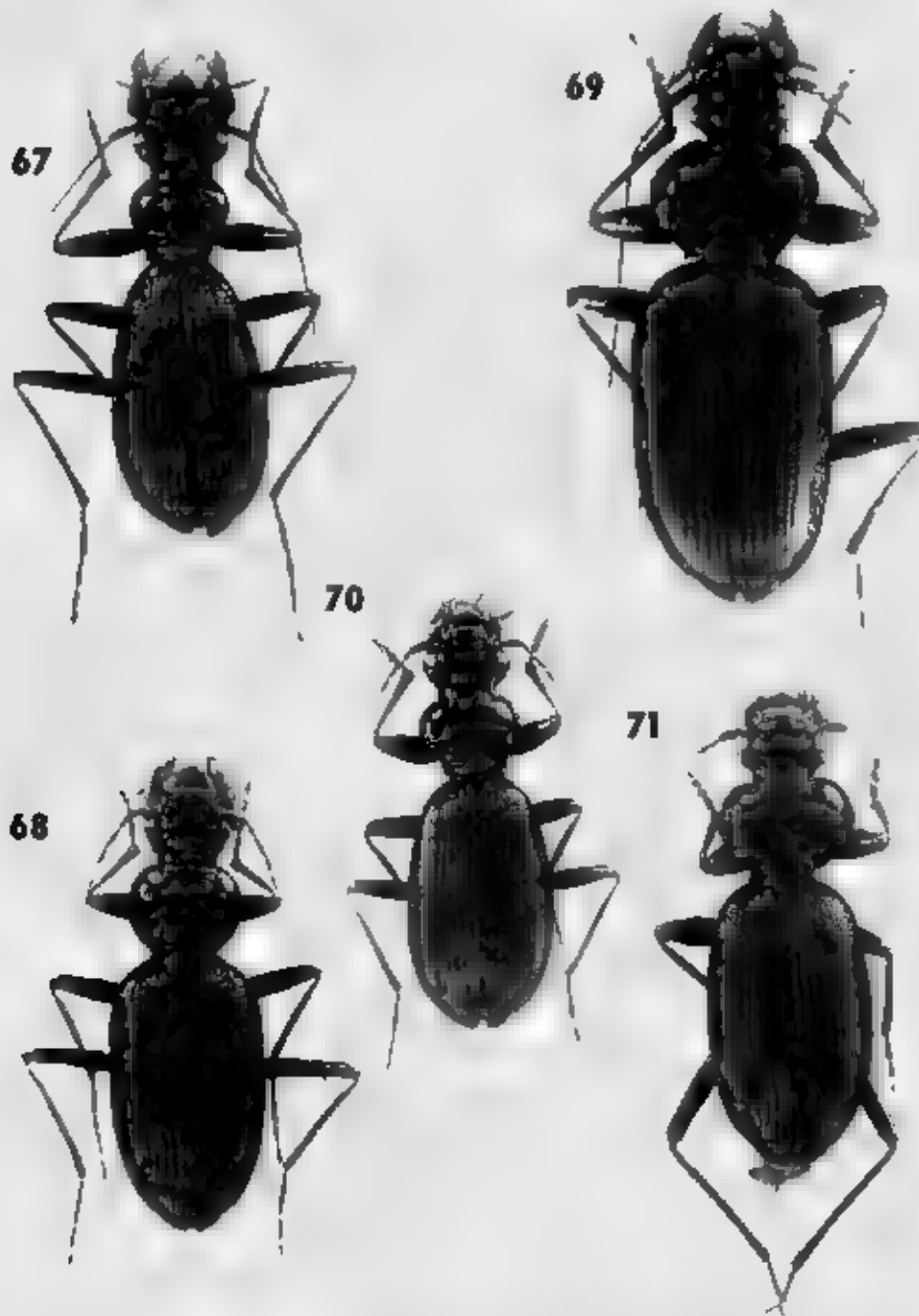


Plate 4 Figs 67-71 Habitus of holotypes of 67 - *L. smetswadi* sp. n., 68 - *L. kralli*, Farkač 1993, 69 - *L. kubani*, Farkač 1993, 70 - *L. janae* Farkač & Platenko, 1992, 71 - *L. angulicollis* Fairmaire, 1886 (lectotype).

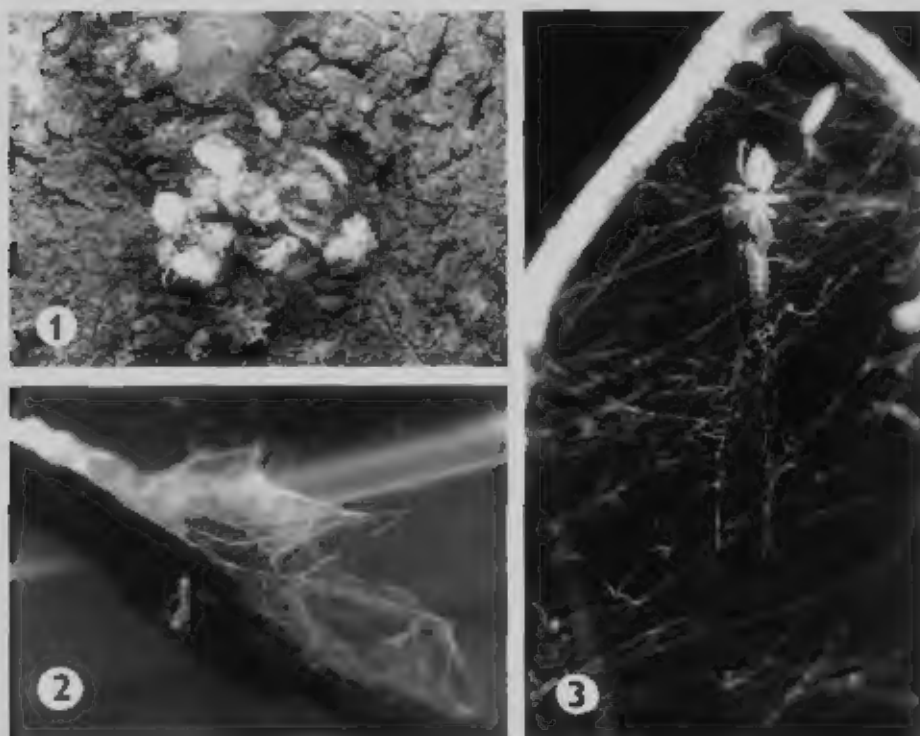


Plate 5. Figs 1-3. 1- aggregation of cocoon-like over-wintering nests of *Pseudictus encarpatus*. 2 - tent-shaped resting nest of *P. encarpatus*. 3 - female *P. encarpatus* with prey in prey-catching widely spaced three-dimensional "mesh".

VIŠNĚK J.: Mating behaviour of *Aphodius (Chiloithorax) distinctus* (Coleoptera: Scarabaeidae: Aphodiinae)

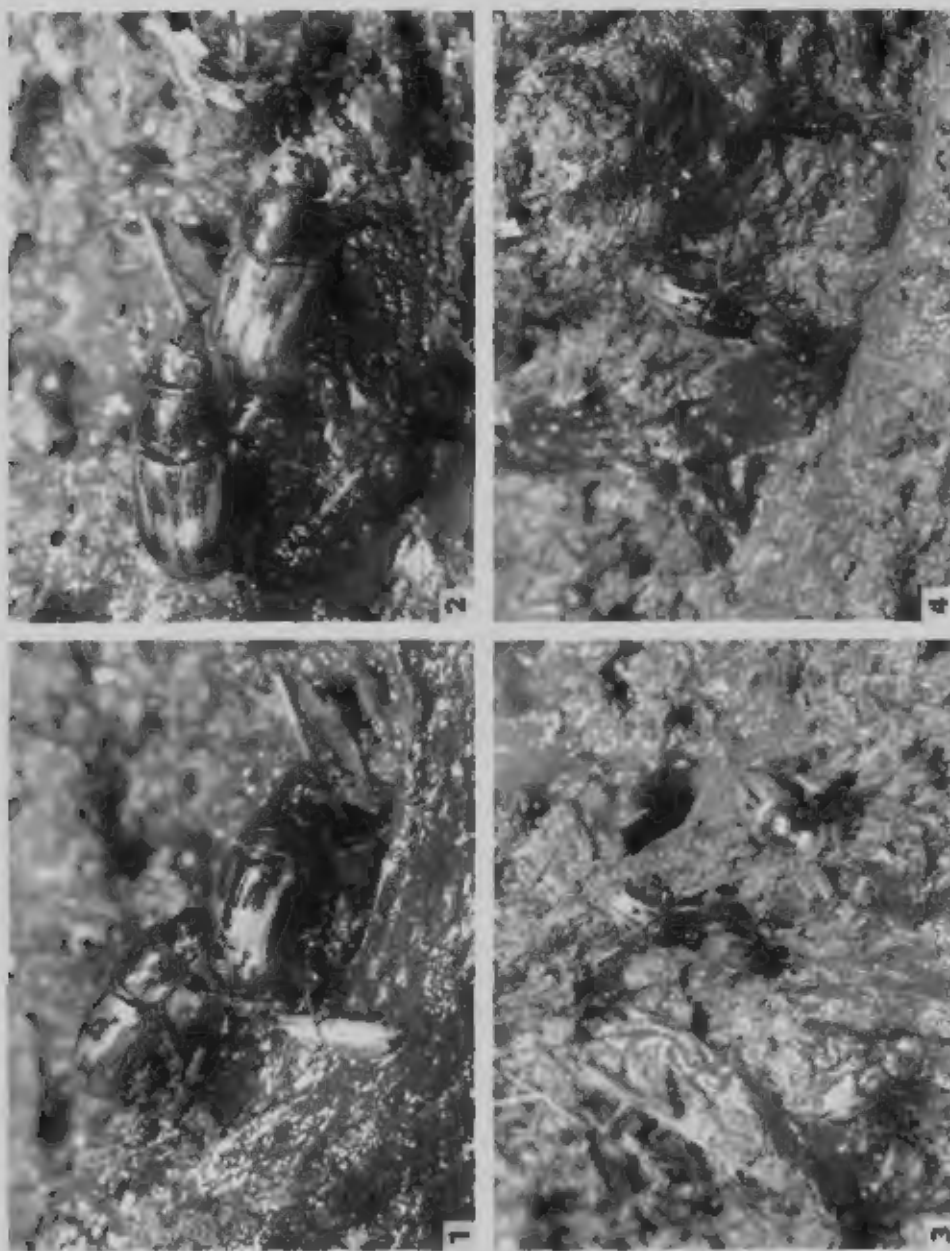


Plate 5. Figs 1-4. Pairs of *A. distinctus* moving in the chained position on the surface of a cattle dung. All photographs by P. Šrůta.

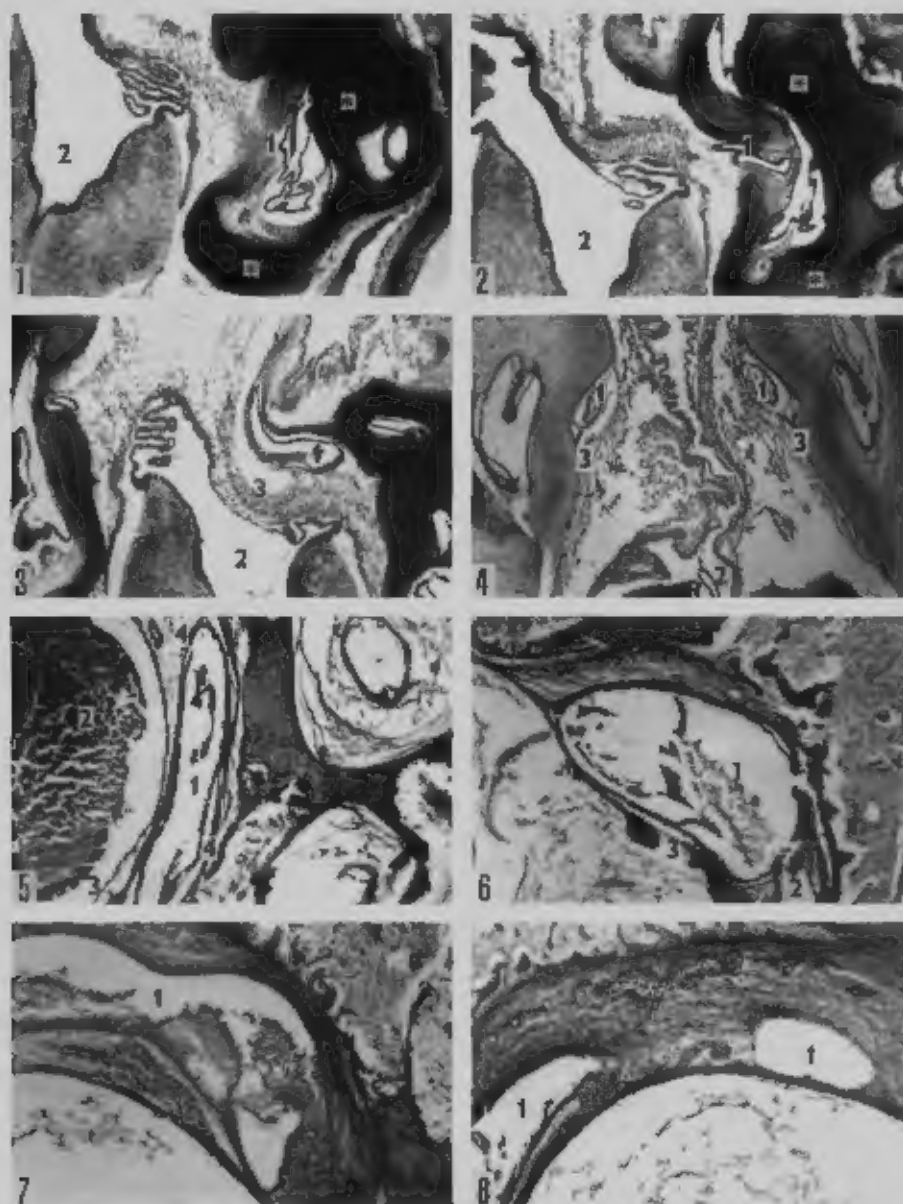


Plate 7. Figs 1-8. Prenatal development of Ductus (DE) and Saccus endolymphaticus (SE) of *Alligator mississippiensis*. Paraffin sections stained with hematoxylin-eosin. Figs 1-3. Embryo head 11.6 mm. 1 - DE, 2 - IV<sup>th</sup> ventricle of the brain, 3 - cartilage tissue, 3 - connective tissue, x 35. Fig. 4. Embryo head-length 14.9 mm. 1 - DE forms two ovoid vesicles in the connective tissue, 2 - IV<sup>th</sup> ventricle of the brain, 3 - duplication of dura mater, x 35. Fig. 5. Embryo head-length 33.1 mm (before incubation). 1 - DE with amorphous material in lumen, 2 - CNS, 3 - leptomeninges, 4 - dura mater, x 125. Figs 6-8. Embryo head-length 33.1 mm (before incubation). 1 - SE with amorphous material in lumen, 2 - DE, 3 - dura mater, x 125.

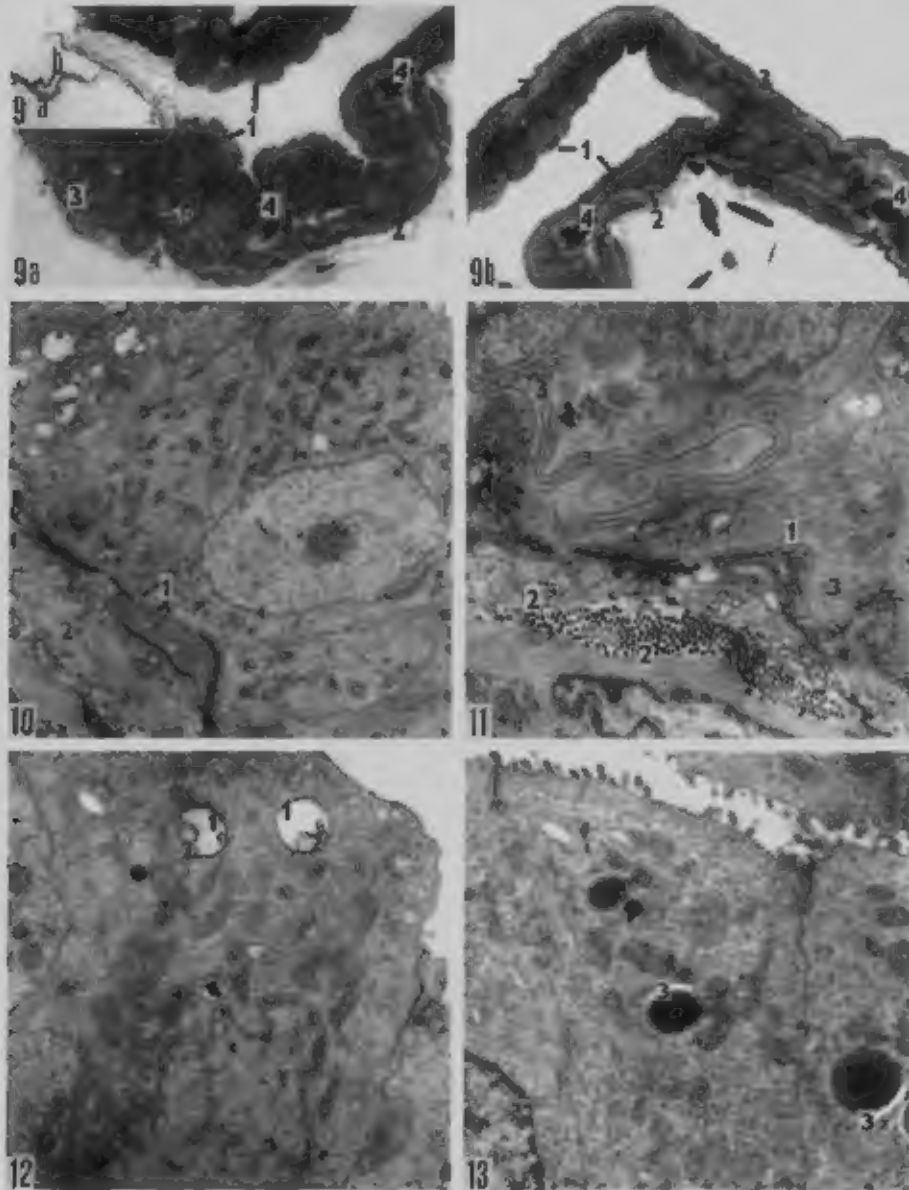


Plate 8. Figs 9-13. Figs 9, 9a, 9b. SE of *Phrynocephalus versicolor*, semithin sections stained with 0.2 % azur in combination with 2 % basic fuchsin. Fig. 9. Saccus endolymphaticus in connection to dura mater.  $\times 15$ . Figs 9a-9b show epithelial cells lining SE with a light and dark vacuoles in cytoplasm (1), 2 - basement membrane, 3 - subepithelial connective tissue of dura mater, 4 - blood vessels.  $\times 750$ . Figs 10-13. Electronograms. Ultrathin sections stained with 2% uranyl acetate and after Reynolds. Fig. 10. The columnar epithelial cells lining SE rest on basal lamina (1); subepithelial connective tissue (2).  $\times 12,000$ . Fig. 11. Basal part of epithelial cells lining SE: 1 - basal lamina, 2 - subepithelial connective tissue, 3 - invagination of the cytoplasm.  $\times 20,000$ . Figs 12-13. The cells with light vacuoles (1) and groups of small light vesicles (2), dark vacuoles (3).  $\times 27,000$ .